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1956, No. 2 COPEIA May 29

The Life History of the Slimy Salamander, *Plethodon glutinosus*, in Florida

RICHARD HIGHTON

PLETHODON glutinosus occurs throughout most of eastern United States. Although not uncommon in most of its range, little is known about its life history. Humphrey (1925) studied the testes of this and other species of salamanders in New York and correlated the condition of these organs with the breeding season. Burger (1937) also studied the testes of plethodontid salamanders in the northeastern United States and made further contributions to the knowledge of seasonal cycles in male *Plethodon glutinosus*. Bishop (1927) speculated on the life history of this species in western New York. Noble and Marshall (1929) discovered two clutches of eggs in caves in Arkansas and described the eggs and embryos. Fowler (1940) found a female guarding a clutch of eggs in West Virginia, and Bishop (1941) added a few notes on development to maturity. Pope and Pope (1949) studied growth and reproduction in southwestern Virginia, and Pope (1950) recorded a courtship dance in the same region. To my knowledge there have been no studies on the life history of the slimy salamander in the southeastern coastal plain.

The purpose of the present study was to obtain detailed information on the life history of *Plethodon glutinosus* in Florida. Part of the present work was presented to the Graduate Council of the University of Florida in partial fulfillment of the requirements for the degree of Master of Science.

MATERIALS, METHODS AND ACKNOWLEDGEMENTS

A total of 663 specimens of *Plethodon glutinosus grobmani* was collected from October, 1951, to October, 1953, at 18 localities in six counties in northern peninsular Florida. An additional 18 specimens were collected on December 29, 1953, and data from some of these have been included in the section on the first appearance of the young. Specimens used in this study were collected in the following counties: Alachua, Clay, Columbia, Lake, Marion and Volusia. It is unfortunate that this study could not have been restricted to specimens from a single locality, but in Florida, as Carr (1940: 47) stated, this species is "frequently found, but nowhere in great numbers." This disadvantage was offset by climatic conditions which made it possible to collect salamanders during every month of the year. By making monthly collections, it was possible to observe all stages of the reproductive cycle as well as to follow the growth of the young for an entire season.

Specimens brought back to the laboratory were killed in chlorotone, measured with a rule to the nearest millimeter before preservation (and its accompanying shrinkage) in 6 percent formalin. Except as otherwise indicated, all lengths referred to are snout–vent lengths, measured from the tip of the snout to the anterior angle of the vent. Specimens were weighed on a trip balance to the nearest hundredth of a gram. Dispersions used in this paper are standard errors.

I wish to thank the following persons for their aid in collecting specimens used in this study: Charles G. Adams, Claude T. Adams, Walter Auffenberg, Miss Marjorie Briggs, Archie Carr, John W. Crenshaw, Mrs. Helen T. Gaige, Keith Hansen, Albert H. Highton, Richard M. Johnson, John J. McCoy, John S. Mecham, Wilfred T. Neill, Howard T. Odum, William C. Sloan and Sam R. Telford. Karl P. Schmidt kindly permitted me to examine a series of 125 specimens of *Plethodon glutinosus* in the collection of the Chicago Natural History Museum. Keith Hansen and Paul J. Osborne generously helped by sectioning testes for histological examination. I also wish to express my appreciation to the members of my Graduate Supervisory Committee and others on the staff of the University of Florida who have made numerous helpful suggestions during the course of this study: Drs. W. C. Allee, Pierce

Brodkorb, Archie Carr, Richard A. Edwards, Coleman J. Goin and Howard T. Odum. Principally, I am indebted to the Chairman of my Graduate Supervisory Committee, Dr. Arnold B. Grobman, who has on numerous occasions given advice for which I am most grateful. I also wish to thank Messrs. Walter Auffenberg, John W. Crenshaw, Richard M. Johnson and Wilfred T. Neill for much helpful advice and criticism. Miss Esther Coogle made the drawings of the newly hatched young and Charles G. Adams took the microphotographs from which the drawings of the gonads and ducts were made. My father proofread the manuscript; my wife typed it and has given aid in countless other ways during the progress of this work.

Reproductive Cycle in Females

The gonads of adult females collected during each month of the year have been examined with the aid of a dissecting microscope. After the egg-laying season (late August and early September) the spent females have small ovarian eggs, the largest of which range from 0.5 to 1 mm. in diameter. By March, the largest eggs have increased to from 1 to 1.75 mm.; in May, 2.5 mm.; in June, 3 mm.; and in July, 3.5 mm. Only one mature female was taken just prior to the egg-laying season in August. Its largest ovarian eggs ranged from 3.5 to 4.5 mm. in diameter. In one unspent individual taken on September 9, 1952, they were 4 mm. (Fig. 1 A).

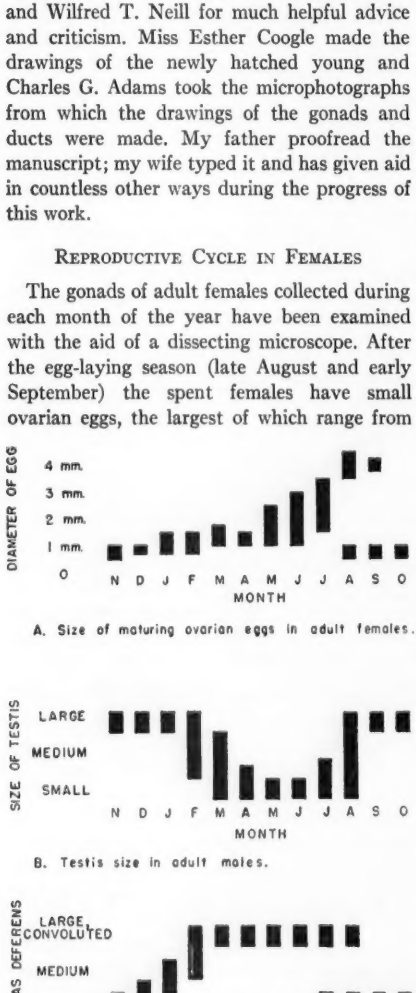

Fig. 1. Seasonal changes in size of maturing ovarian eggs, of the testis and vas deferens.

The oviducts of mature females are large and convoluted from May or June until after the egg-laying season in October or November. They are largest during August and September. During the winter months they are thin and fairly straight.

Unfortunately, few adult females were collected during the summer months. All mature females taken in July had large ovarian eggs, and one taken on August 12, 1952, was also in this condition. A specimen collected on August 29, 1952, however, was spent. Its oviducts were very large and convoluted and there were structures resembling fat bodies in the ovaries, presumably unlaid eggs in the process of being resorbed. This indicates that *Plethodon glutinosus* begins to lay its eggs in Florida before the end of August. On September 9, 1952, two large females were collected at O'Leno State Park, Columbia County. One, a 63-mm. specimen, had large ovarian eggs that could be seen through the belly wall. The oviducts were very large and convoluted but did not contain eggs. The other, 64 mm. in length, was discovered under a log, guarding a clutch of eight eggs, which were in the gastrula stage. In this female the ovaries and oviducts were in the same spent condition as in the specimen described above, taken on August 29. All other adult females collected after September 9, in both 1952 and 1953, were spent.

On September 16, 1952, at O'Leno State Park, a 55-mm. female was found inside a rotting log with a clutch of 11 eggs, attached at a single point to a small root. The embryos were large and flexed sporadically. The female was marked and placed with the eggs in a small depression scooped out in the log and then covered with bark. The salamander apparently abandoned the nest, for it was not found with the eggs on either September 21 or 28. The eggs were then brought back to the laboratory and placed in an amphibian hatching pot (Goin,

1947: 2). Three of these eggs hatched on October 10 and 11, but the hatchlings died, probably killed by nematode worms that were found covering them, being most abundant on their small gills.

On September 28, 1952, two more clutches of eggs were discovered at O'Leno State Park. A 57-mm. female was found guarding a clutch of 10 eggs under a large log. Six of these eggs, which were also brought back to the laboratory and placed in a hatching pot, hatched between October 20 and 30. Another (59 mm. in length) was found under a log coiled about a clutch of seven eggs, attached to a small root hanging above the floor of the cavity in which the salamander lay. The female was not disturbed and the log was carefully replaced. On October 19 and 28, the female was again found with the eggs. This individual was almost certainly the same one found earlier with this batch of eggs. It was recognized on each occasion by a marked reduction of dorsal flecking, a condition rarely found in specimens from this locality. Each time the log was turned and the nest exposed, the salamander moved a short distance away from the eggs. When the nest was examined on November 16, the female was still under the same log, about 2 inches from the eggs, which unfortunately were lost before it was determined whether they had hatched or desiccated. The female was then measured, marked and released. On this date she was extremely thin. She was recaptured on December 6 under an adjacent log 2 feet from the former position of the nest. On May 8, 1953, she was found dead in the cavity where the eggs were laid. At this time her ovaries were examined and maturing eggs were found which would doubtless have been laid in the coming season. The fact that all specimens over 56 mm. in snout–vent length have maturing eggs in their ovaries supports the conclusion that females lay eggs every year.

On October 17, 1953, Richard M. Johnson found a 53-mm. spent female coiled about a batch of at least nine eggs under a log at O'Leno State Park. One of these eggs was accidentally destroyed, but eight were brought back to the laboratory and placed in a hatching pot. All eight hatched between October 27 and November 1 (Fig. 3).

One of the two clutches of eggs that Noble and Marshall found in Arkansas and those that Fowler discovered in West Virginia had females in attendance. However, 18 recently spent females were collected away from their nests during the months of August, September and October. It has been noted above that a female that remained with her eggs for at least a month and a half was extremely thin at the end of this period. In another individual found with her eggs the stomach contained a small amount of food. It is possible that the 18 spent females collected away from their nests were foraging for food, but it is also possible that they had abandoned their nests or that their eggs had been destroyed by predators. The eggs of some of the females (14 of the 18 were collected in October) may, of course, have already hatched.

Reproductive Cycle in Males

The testes of all mature males taken during the months of May and June are very small in diameter, but there is a progressive increase in size during July and August. From September until the middle of February, the testes remain large and swollen; then they decrease rather rapidly in size so that by the middle of April their diameter is very small and the surface pigment is so concentrated that they appear very dark (Fig. 1 B).

In order to determine the time at which the spermatogenetic wave passes through the testes, smears were made of tissue from different parts of a testis of specimens taken during each month when the testes are large and swollen. Spermatozoa were first found in the posterior part of the testis of specimens taken during the middle of October. By the middle of December the spermatogenic wave had passed through the testis, as evidenced by spermatozoa in its anterior end. There was a considerable amount of individual variation in the position of the spermatogenic wave at any one time, so these dates suggest only an approximation of the time it takes the wave to pass through the testis.

The testes of all mature males taken during the months of January, February and March are swollen and packed with sperm. By the middle of April, spermatozoa are no longer present and the testes are small. No spermatozoa were found in the testes of any males taken between the middle of April and the

middle of October. Spermatozoa are first found in the posterior end of the testes in October, about two months after their enlargement.

The vasa deferentia of mature males are small and threadlike from mid-summer until the end of December when they begin to enlarge slightly. By late February, they are very large and much convoluted. They remain in this condition until the mid-summer breeding season. (Figs. 1 C, 2 A, 2 B.)

Smears of vasa deferentia reveal that they are devoid of sperm from mid-summer until late December. Spermatozoa are first present at the end of December, at the same time that there is the first slight enlargement of the vasa deferentia. By mid-February all mature males have vasa deferentia filled with sperm. They remain swollen and convoluted and packed with sperm until the mid-summer breeding season.

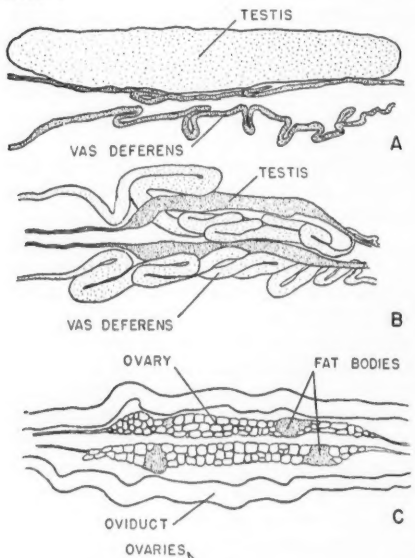

Fig. 2. Male and female gonads and their ducts. Males: A—condition in a specimen taken Dec. 16, 1951 (one testis removed to show vas deferens); B—condition in one taken June 6, 1952. Females: C—spent individual (55 mm. snout-vent); D—unspent individual (56 mm. snout-vent). Both females collected Sept. 28, 1952.

During July and August, no mature male was ever found with spermatophores in the cloaca, and smears of the cloacal fluid did not reveal spermatozoa. Only preserved individuals were examined, however. In males taken during this period the vasa deferentia were large, convoluted and packed with sperm or were tiny and thread-like and completely devoid of sperm. No specimens were found to be in an intermediate condition. Males with large sperm-packed vasa deferentia were taken on June 6, 22 and 29, and August 7, 1952, and on June 8 and July 4, 1953. Specimens with small thread-like vasa deferentia devoid of sperm were collected on August 10, 12 and 29, and September 9, 1952, and on July 23 and 30, August 16 and September 17, 1953. (Figs. 1 C, 2 A, 2 B). Courtship activity and the picking up of spermatophores, therefore, probably occur between mid-July and mid-August, several weeks before the females lay their eggs.

The mental gland is present throughout the year in mature males, but is largest and most conspicuous during July and August. Cloacal papillae and small, round, yellow or orange glands on the belly are additional secondary sexual characteristics present in adult males throughout the year.

Development to Maturity

Description of Newly Hatched Young.—Noble and Marshall (1929) described and figured the embryos of *Plethodon glutinosus* found in Arkansas caves, but newly hatched young have not previously been reported or described. Bishop (1941: 226) was correct in believing Noble and Marshall's 16-mm. larvae were near hatching. The following description (specimen viewed under magnification of a dissecting microscope) is of a salamander that hatched on October 24, 1952. It is from a clutch of 10 eggs collected at O'Leno State Park, on September 28, 1952, and incubated in a hatching pot in the laboratory.

Snout-vent length, 12 mm.; total length, 20 mm.; head length, 4 mm.; head width, 3 mm. The heart and accompanying blood vessels are visible through the body at the gular fold. There is no black pigment on the throat or belly, but a narrow rim is present around the edge of the lower jaw. A slight groove extends from the head (1 mm. posterior to the level of the eyes)

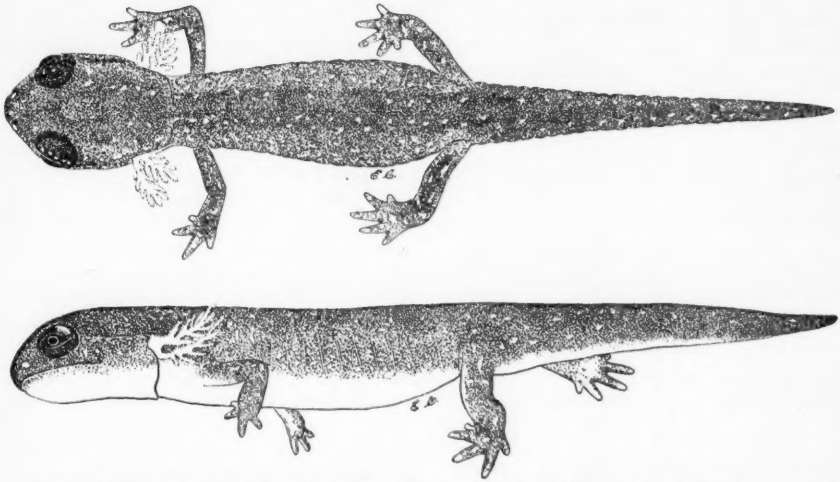

Fig. 3. Dorsal and ventrolateral views of a newly hatched *P. glutinosus*. Hatched October 28, 1953; snout-vent length, 14 mm., total length 22 mm.

to the tip of the tail along the mid-dorsal line. Pigment is present in this groove on the body, but is absent on the tail. Paired dorso-lateral blood vessels are visible 0.5 mm. on each side of the mid-dorsal line. The dorsum is uniformly black, except for very small pigment-free areas (0.1 mm. in diameter); these become larger and more numerous laterally and give the sides a lighter appearance. Pigment is absent from the costal grooves, which begin at the level of the dorso-lateral blood vessels. There is no black pigment on the belly ventral to the level of the limb insertions, nor on the ventral surface of the limbs and the underside of the tail. The black pigment is slightly more concentrated in the head region and the large eyes are very dark. The dorsal surface of the digits is slightly pigmented.

There is a very large amount of yolk extending from the level of the posterior margin of the front limbs to the anterior border of the hind limbs. It extends ventrally and laterally beyond the body profile, especially in the posterior region of the belly. The gills are rudimentary, the longest being 1.3 mm.

The gills were entirely resorbed within 2 or 3 days after hatching. So much yolk material was present in newly hatched specimens that they had difficulty in walking; the hind limbs could not move forward, being hindered by the immense quantity of yolk. Within a day after hatching, however, they were climbing up the sides of the container. Although the young appear to have tiny white spots on the dorsum at hatching, as described above, the spots are merely pigment-free areas. Within 2 or 3 days after hatching, larger pigmented white flecks appeared on the back. These soon changed in color to the bright metallic yellow flecks characteristic of specimens from northern Florida.

Four of the salamanders that hatched between October 20 and 30, 1952, survived. By November 4, they moved quite rapidly when disturbed. On November 23, one had used up all its yolk, two had very little yolk remaining, while the fourth had a considerable amount left. They were then fed *Drosophila melanogaster* which they readily accepted. Their growth during the first 3 months corresponded closely with that of salamanders taken in the field during the winter of 1952–1953 (Fig. 6).

The eight specimens that hatched between October 27 and November 1, 1953, agreed in most respects with those described above, except that they appeared to be at a somewhat more advanced stage. There was not as much yolk material and the specimens were larger (Fig. 3). The weights of five of these individuals, taken on a quantitative balance, were between 0.08 and 0.09 g. Hatching dates, snout-vent length and total length (in mm.) of the eight salamanders are as follows: October

TABLE I

LENGTHS (IN MM.) OF YOUNG-OF-THE-YEAR *Plethodon glutinosus* COLLECTED DURING THE WINTERS OF 1951–52, 1952–53 AND 1953–54

Asterisk denotes part of tail missing

Date collected	Snout-vent length	Total length
Dec. 26, 1951	17.0	27.0*
	17.5	25.5*
	17.5	25.0*
Jan. 1, 1952	18.5	35.0
	17.0	32.0
	18.0	32.0
	17.5	32.5
	17.0	26.0*
Dec. 28, 1952	16.0	32.0
	15.0	28.0
	17.0	32.0
Dec. 31, 1952	16.0	30.0
Dec. 29, 1953	18.0	35.0
	19.0	34.0

27—14, 25 (2), 13, 24 (1); October 28—14, 22 (1); October 29—14, 25 (1), 14, 24 (1); November 1—15, 26 (1), 14, 25 (1).

FIRST APPEARANCE OF THE YOUNG.—All three clutches of eggs that were kept in the laboratory hatched during October, but the young of the year were not discovered in the field until the end of December. Collecting at four localities during the first 2 weeks of December, 1951, yielded 21 slimy salamanders, none of which was a newly hatched young, but among 28 specimens taken on December 26, 1951 and January 1, 1952, were eight newly hatched young (Table I). Similarly, there were no hatchlings among 16 specimens from two localities on December 6 and 18, 1952; but of 35 individuals taken at five localities on December 28 and 31, 1952, four were newly hatched. No collections were made during early December, 1953, but of 18 specimens taken on December 29, 1953, two were new young of the year.

Bishop (1941: 226) measured three young specimens from New York, collected on July 10, 15 and 19, 1924. Their total lengths were 34, 31 and 30 mm. It is very evident that the young appear at a different season in Florida. Bishop's specimens had about the same total length as the two-month-old Florida specimens taken in late December. This would indicate that egg-laying takes place in New York during March and hatching in May, if the duration of development of the young is similar to that in Florida. Bishop (1941: 224) believed that in New York the eggs are deposited some time between December and May, but was unable to determine the specific period of egg-laying.

GROWTH.—In December, 1951, and early January, 1952, when the first young of the year were found, it was at once noted that there was very little variation in the lengths of the eight individuals of this age group. This seemed to indicate that this species, unlike many other salamanders, has a rather limited breeding season and would thus be an excellent subject for the study of growth of salamanders under natural conditions. The variation in size groups at a specified time would therefore not reflect the additional variation resulting from an extended hatching period. Dempster (1930) made a similar study on the aquatic larvae of *Ambystoma maculatum*.

All specimens taken through May, 1952, were killed in chlorotone and measured before preservation. Beginning in June, 1952, some specimens were marked and released at four different localities in Lake, Marion and Columbia counties. These individuals had to be measured alive in the field and were not weighed. In order to test the accuracy of such measuring, a series of 35 live salamanders of various sizes were measured in the laboratory and immediately killed in chlorotone and remeasured. The total error on snout-vent lengths was 1.8 percent. Since the error was so small, the length data on 153 specimens measured alive have been included in the following section on growth.

The weight of amphibians may be increased considerably through dermal water absorption (Stebbins, 1945: 26). For this reason all live specimens were placed in jars with moist paper towels for several hours before weighing.

Specimens taken through the middle of June, 1952, were weighed several months after preservation. As a test of this procedure, the same 35 specimens measured above were weighed alive and after preservation in 6 percent formalin. Fifteen specimens were weighed again 3 days after preservation and the other 20 were weighed 8 months after preservation in formalin. The total error on the weights was 5.4

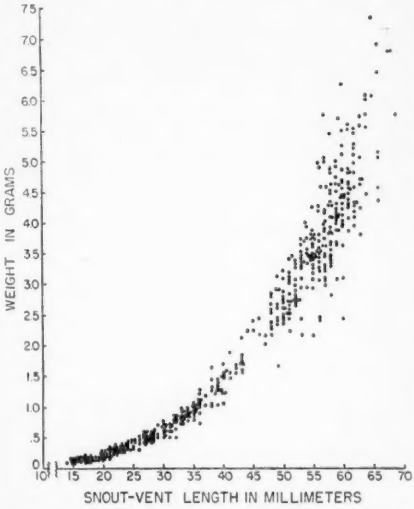

Fig. 4. Relationship of weight and snout-vent length in equation for this curve is: Weight = 5.31×10^{-5} (length)$^{2.76}$.

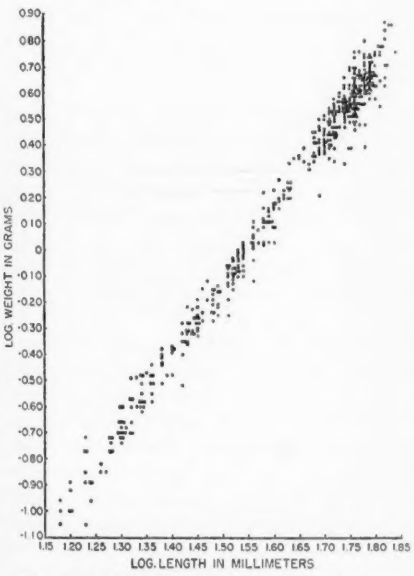

Fig. 5. Relationship of weight and length plotted on logarithmic coordinates.

percent, that of the former group 2.0 percent, and that of the latter group 7.4 per cent. It is unfortunate that only about half of the specimens were weighed alive, but since the test errors were found to be so small, the weights of preserved animals were included in the calculations on the relationship of weight to length (Figs. 4 and 5). Furthermore, the equations for the curves of the two different samples, weighed alive and preserved, when calculated by the product-moment method were very similar: weight = 6.63×10^{-5} (length)$^{2.70}$ for the live ones, and weight = 1.59×10^{-5} (length)$^{2.83}$ for the preserved ones.

Length and weight data were plotted on double logarithmic coordinates (Fig. 5) in order to determine the nature of the equation of the relationship. The data plotted on logarithmic coordinates produce a straight line, thus indicating that the original curve (Fig. 4) is of the form

$$W = aL^n$$

where W is the weight in grams, L is the snout-vent length in millimeters and a and n are constants. The slope of the straight line of the logarithmic equation, n, obtained by the product-moment method (Simpson and Roe, 1939), is equal to 2.76. The relationship between length and weight for the 484 specimens weighed may thus be expressed by the formula

$$\text{Weight} = 5.31 \times 10^{-5} (\text{length})^{2.76}$$

If the form and specific gravity of an animal remain constant throughout life, the weight during growth will increase in direct proportion to the cube of the length. In this salamander, however, the weight increased at a slightly lower rate ($n = 2.76$) showing that in Florida *Plethodon glutinosus* has a change in specific gravity or body form (or both) during growth and thus becomes proportionately lighter or more slender with increased length. The body form is probably a more important factor in this regard. It would be desirable to compare growth of this species in other areas, since both the average and the maximum size attained are less in Florida than in most other parts of its range. Several specimens of *Plethodon glutinosus albagula* from Texas, for example, because of their thinner body and greater length did not fall within the limits of the range of Florida specimens. A significantly different curve might be expected for the Texas race.

An attempt was made to collect the samples of juveniles at the end of the month or at the

Fig. 6. Snout–vent length in relation to date of collection. Crosses = hatchlings reared in laboratory from October, 1952, to January, 1953.

beginning of the succeeding month. Specimens collected on or before the 17th day of the month were included with the previous month's sample; those collected after that date were included in the next month's.

The length and weight increase of the young of the year is such that those taken in June average almost twice as long and six times as heavy as those found in late December (Tables I and II).

I was unable to determine the sex of juveniles until they reached a snout–vent length of about 35 mm. during the summer following hatching. At this time the monthly samples were not large enough to determine whether or not there was any sexual dimorphism in growth rate. Pope and Pope (1949: 258) found that the snout–vent length of females from the southwestern Virginia mountains averages slightly larger than that of males. Also, Orton (1946: 107) found that in Pennsylvania and West Virginia the female is slightly larger. The same situation obtains in the Florida populations. In specimens 55 mm. or more in length (Table III) the difference between the sexes is statistically significant. The application of a standard *t*-test to these data gives a probability ($t = 3.22$) of 0.0013 of obtaining a difference between the means in the absence of sexual dimorphism as great or greater than that obtained. Although some specimens under 55 mm. are mature, this length was chosen because all individuals (except for one 55-mm. and two 56-mm. females) over 54 mm. were mature. Were all mature individuals included, the difference in size between males and females would be even more significant because of the preponderance of males among mature specimens under 55 mm. in length.

As Allen and Neill (1949: 113) have stated, *Plethodon glutinosus* is smaller in Florida than in the northern parts of its range. This is true in both average and maximum size of the Florida population. It would thus seem that Bergmann's Rule applies also to *Plethodon glutinosus*. This species is an exception to the so-called "Reverse Bergmann Rule" for cold-blooded vertebrates.

Although much more time and effort were expended during the summer months, the yield of salamanders of all size groups was very poor. Allen (1932: 4) found this species to be the commonest salamander in Harrison Co., Mississippi, during the winter, "but at the approach of warm weather they become scarce in their winter retreats, and with the advent of summer they seem to disappear, as only an occasional one can be found." This species has been found deep in the ground during dry spells (Bishop, 1941: 228). However, in Florida, there is increased rainfall during the summer months, so higher temperatures or a combination of increased temperature with its accompanying higher evaporation rate may be factors inhibit-

TABLE II

SNOUT-VENT LENGTHS AND WEIGHTS OF JUVENILES OF *Plethodon glutinosus* IN MONTHLY SAMPLES COLLECTED FROM DECEMBER 26, 1951, TO OCTOBER 17, 1953

Date	Snout-vent length (mm.)			Weight (g.)		
	Number	Range	Mean	Number	Range	Mean
1951–1952						
Dec. 26–Jan. 1	8	17–18.5	17.5 ± 0.18	8	0.09–0.14	0.13 ± .006
Jan. 31–Feb. 9	18	17–23	21.2 ± 0.35	18	0.17–0.33	0.25 ± .012
Feb. 24–March 2	12	20–25	22.1 ± 0.43	12	0.19–0.42	0.27 ± .020
April 10–11	13	23–28	26.2 ± 0.53	13	0.33–0.59	0.46 ± .023
May 7–11	10	27–31	28.7 ± 0.42	10	0.45–0.75	0.58 ± .030
June 6–11	16	24–35*	31.0 ± 0.71	16	0.31–0.98*	0.72 ± .044
June 22–July 1	10	30–36*	32.7 ± 0.62	..	..	0.80†
Aug. 7–14	6	29–38*	34.3 ± 1.19	..	..	0.92†
Aug. 26–Sept. 16	14	29–40*	34.9 ± 0.88	..	..	0.96†
Sept. 21–Oct. 12	14	34–44*	38.4 ± 0.72	..	..	1.25†
Oct. 19–Nov. 16	18	32–45*	39.4 ± 0.75	..	..	1.35†
1952–1953						
Dec. 28–31	4	15–17	16.0 ± 0.35	4	0.09–0.13	0.12 ± .008
Feb. 3–12	18	15–21	18.8 ± 0.47	18	0.10–0.27	0.19 ± .013
March 15	4	22–25	22.8 ± 0.65	4	0.26–0.41	0.32 ± .031
April 5	9	21–28	25.1 ± 0.71	9	0.32–0.56	0.43 ± .025
May 8	15	25–35*	30.6 ± 0.80	15	0.33–0.95*	0.69 ± .050
June 8	9	26–39*	32.0 ± 1.31	9	0.30–1.30*	0.74 ± .104
July 4	5	27–35*	30.4 ± 1.37	5	0.50–0.96*	0.65 ± .076
July 23–Aug. 16	15	30–38*	33.9 ± 0.59	15	0.60–1.22*	0.91 ± .046
Aug. 18–Sept. 17	9	26–40*	34.6 ± 1.30	9	0.40–1.50*	1.02 ± .108
Oct. 17	6	35–41*	37.7 ± 0.99	6	0.94–1.56*	1.18 ± .082
Total: 1951–1953						
Dec. 26–Jan. 1	14	15–19	17.2 ± 0.29	12‡	0.09–0.14	0.12 ± .005
Jan. 31–Feb. 12	36	15–23	20.0 ± 0.36	36	0.10–0.33	0.22 ± .010
Feb. 24–March 15	16	20–25	22.3 ± 0.37	16	0.19–0.42	0.28 ± .019
April 5–11	22	21–28	25.7 ± 0.43	22	0.32–0.59	0.45 ± .017
May 7–11	25	25–35*	29.9 ± 0.55	25	0.33–0.95*	0.64 ± .034
June 6–11	25	24–39*	31.4 ± 0.66	25	0.30–1.30*	0.73 ± .047
June 22–July 4	15	27–36*	31.9 ± 0.68	5	0.50–0.96*	0.65 ± .076
July 23–Aug. 16	21	29–38*	34.0 ± 0.54	15	0.60–1.22*	0.91 ± .046
Aug. 18–Sept. 17	23	26–40*	34.8 ± 0.74	9	0.40–1.50*	1.02 ± .108
Sept. 21–Oct. 17	30	34–44*	38.2 ± 0.60	6	0.94–1.56*	1.18 ± .082
Oct. 18–Nov. 16	23	32–46*	39.9 ± 0.73	8	0.56–1.71*	1.12 ± .127
Dec. 6–9	12	34–46*	41.5 ± 1.20	7	0.84–1.81*	1.35 ± .136

* There may be some overlap with the previous year's age group at the upper limits of this size range. Some of the year older age group may have been included in these data and some of the larger specimens of this age group may have been omitted. Thus the actual mean may have been slightly influenced.

† Since most of the specimens collected after June, 1952, were marked and released, their average weight was calculated from the mean snout-vent length by means of the formula for the length-weight relationship (Fig. 4): weight = 5.31×10^{-4} $(\text{length})^{2.76}$.

‡ Lengths of two newly hatched specimens collected in December, 1953, after the two-year study was completed, are included in the first month's sample; weights were not taken.

TABLE III

THE SNOUT-VENT LENGTHS OF ALL MALES AND FEMALES OF *Plethodon glutinosus* 55 MM. OR OVER

Snout-vent length	Males	Females
55	17	16
56	12	16
57	22	12
58	15	16
59	14	14
60	12	16
61	4	15
62	9	10
63	5	6
64	1	5
65	1	3
66	..	6
67	..	..
68	..	2
69	..	1
Total	112	138
Mean	58.2 ± 0.23	59.4 ± 0.28

TABLE IV

THE SNOUT-VENT LENGTHS OF THE COMBINED MONTHLY SAMPLES OF SPECIMENS OF *Plethodon glutinosus* IN THEIR SECOND YEAR OF GROWTH

Maturity of the female gonads was the basis on which the upper limits of the size range of this age group was estimated. The data obtained by this method are only approximate

Dates collected	Snout-vent length (mm.)		
	Number	Range	Mean
Dec. 18–Jan. 3	22	31–48	39.6 ± 0.82
Jan. 31–Feb. 12	10	31–48	40.8 ± 1.48
Feb. 24–March 15	10	41–52	46.3 ± 1.10
April 5–10	7	38–49	45.2 ± 1.39
April–May	0	...	...
June 7–11	4	38–53	44.8 ± 3.02
June 22–July 4	7	38–54	49.0 ± 1.81
July 23–Aug. 16	8	44–53	48.8 ± 0.92
Aug. 26–Sept. 17	11	50–55	51.9 ± 0.55
Sept. 21–Oct. 17	9	49–56	52.3 ± 0.72
Oct. 19–Nov. 16	13	47–53	50.8 ± 0.45

ing activity. This summer period of reduced activity corresponds to the decrease in the growth rate of the young (Table II). It is at the end of this period, when the more favorable growing season is nearing approach, that the eggs are laid.

As will be shown in the next section, there is fairly good evidence to indicate that in females, at least, maturity is more closely related to age than to size. Provisionally accepting this to be true, the average lengths of the monthly samples of immature individuals (excluding those considered young of the year) have been calculated. Animals marked and released were included in this group, if their lengths fell within the size range of those in which immaturity was determined on the basis of the condition of the gonads. This age group could be followed up to the October–November sample, the last one after the egg-laying season when it was always possible to determine whether a female had laid eggs. While it is realized that the average monthly length obtained by this method is only approximate, it is believed that the results are a fairly accurate estimation of growth during the second year of life (Table IV). The decreased number of individuals in the second year of growth as compared to the number of young of the year collected may be an indication of the reduction in the number of young surviving to this age.

AGE OF MATURITY IN FEMALES.—By June the young of the year have increased in length at such a rapid rate that the largest are as large as the smallest individuals of the previous year's age group. Because of this overlap in size between specimens of two different age groups, it has been impossible to determine with certainty whether or not all individuals mature at the same age. It was for this reason that the marking of individuals in the field was begun in June, 1952. Unfortunately, only one female in the second-year age group was recaptured the following spring.

The data that have been obtained by dissection have shown rather conclusively that females do not mature until they are 2 years old and therefore cannot lay eggs until they are approaching the age of three. The one female that was recaptured in the spring of its second year did not contain maturing eggs and therefore was not in a condition to lay eggs at the age of 2 years. This specimen will be discussed more fully in the section on growth and maturity of marked specimens.

When it is first possible to distinguish between the sexes of juveniles, the ovarian eggs are about 0.25 mm. in diameter. Twenty females, ranging in size from 31 to 46 mm., taken in

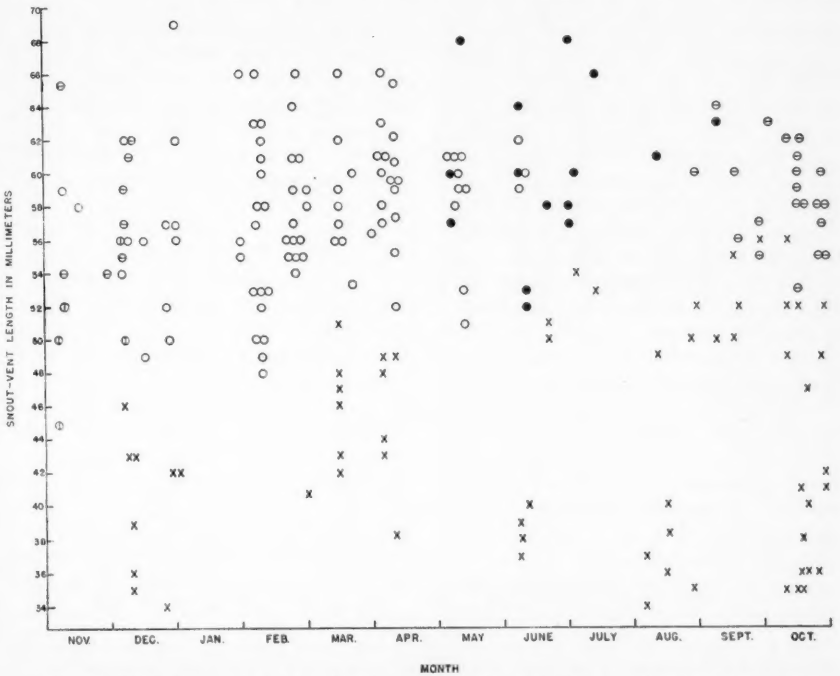

Fig. 7. Condition of the gonads of females taken during each month of the year in relation to snout–vent length. Crosses immature females; disks=mature individuals with ovarian eggs 2 mm. or more in diameter; circles=mature individuals with maturing ovarian eggs of less than 2 mm. in diameter; horizontal line within circles=spent individuals; vertical line within circles=unspent individuals.

October, November and December, were all immature, with tiny eggs in their ovaries. During this same period, all individuals over 46 mm. in length (except for one 45 mm. specimen) had larger maturing eggs between 0.5 and 1 mm. in diameter. This size separation between mature and immature specimens immediately following the egg-laying season presents quite a different situation from that which exists during the summer, just prior to the egg-laying season. At this time, unspent females up to 56 mm. in length were taken with small immature eggs in their ovaries and lacked any large maturing ovocytes. Five spent females collected during September and October were 53, 55 (3) and 56 mm. in length. Since these specimens, the same size as the immature individuals mentioned above, had definitely laid eggs, size is not the sole factor that denotes maturity. When the condition of the gonads of females taken throughout the year is plotted (Fig. 7), the seasonal difference in the size at which the largest immature specimens are found is apparent. This corresponds almost exactly with the expected increase in the size of the largest individuals in their second year of growth. All females in the two-year-old size group in the fall have maturing eggs in their ovaries.

All evidence strongly suggests that females do not mature until they are 2 years old. The overlap in the sizes of mature and immature females seems to indicate that age is the chief factor which determines the time of maturation of the female gonads.

There are obvious gonadal differences between an immature unspent female and one that has recently deposited eggs (Fig. 2 C, 2 D).

Age of Maturity in Males.—The seasonal relationship between size and maturity in males (Fig. 8) shows a pattern essentially similar to that of the females. However, it seems evident that during the winter some of the large males of the one-year-old size group do mature and are therefore in condition to breed the fol-

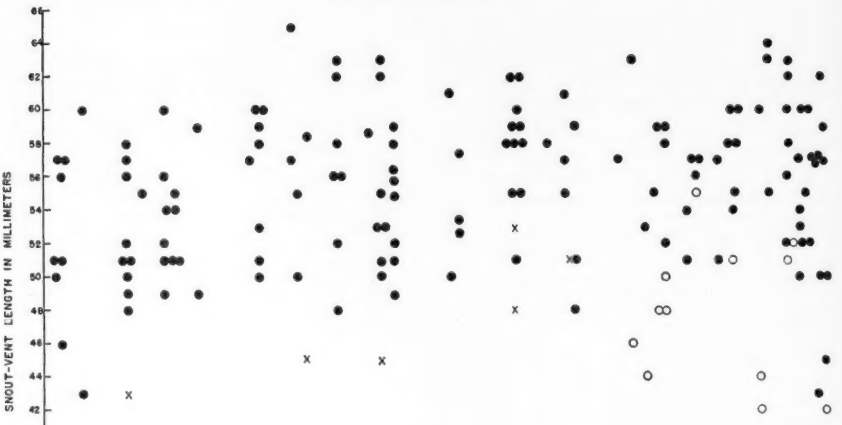

Fig. 8. Condition of the gonads of males taken during each month of the year in relation to snout-vent length. Crosses = immature males; disks = individuals with mature testes and vasa deferentia; circles = individuals with mature testes and immature vasa deferentia.

lowing summer at the age of two. That all two-year-old males do not breed is indicated by the fact that three large ones taken in June and July, measuring 48, 51 and 53 mm. and certainly not young of the year, had immature testes and undeveloped vasa deferentia. Moreover, nine specimens in this size group (44 to 55 mm.) taken during August, September and October had enlarged testes but unpigmented vasa deferentia (Fig. 8), showing that they were maturing but had probably not bred the preceding summer. However, many other males in this size range had vasa deferentia that were pigmented and of the same size as those of larger adults, probably indicating that they had bred the preceding summer. As in females, there is overlap in size between the immature group and the mature breeding males and it is, of course, impossible to determine the exact age of any individual. A juvenile, at least 10 months old was marked in August, 1952, and recaptured in August, 1953. It had maturing gonads, but the vasa deferentia were still unpigmented, doubtless indicating it had not bred during the summer of 1953, when it was almost 2 years old.

Burger (1937) found that one-year-old males of *Plethodon cinereus* collected in New Jersey and Pennsylvania underwent an "abortive sexual cycle." This was shown to result in the non-production of functional spermatozoa because the maturing sex cells, some of which reach the spermatocyte stage, degenerate. It is not until the animals reach their second year that meiotic divisions begin, finally resulting in the production of sperm to be utilized at the age of three.

Some males in the one- and two-year-old size groups of Florida *Plethodon glutinosus* probably do undergo this "abortive sexual cycle"; on the other hand, the testes and vasa deferentia of some individuals of this size group do contain spermatozoa. For example, a 52 mm.-male taken on March 15, 1953, had sperm in the left vas deferens, but not in the right. Thus, the spermatocytes may have degenerated in one testis but not in the other. On the other hand, a 48-mm. male collected on July 4, 1953, and probably not more than 2 years old, had spermatozoa in both vasa deferentia and was, therefore, in breeding condition.

From the above data it seems evident that at the age of one year some males have enlarged testes undergoing meiotic divisions, but others do not. Of those that are undergoing spermatogenesis, some are merely having an abortive sexual cycle which will not result in the production of sperm for the following year's breeding activities; others apparently do develop functional spermatozoa and are capable of breeding at the age of 2 years.

Males in the second-year age group that have enlarged testes, usually also possess mental glands. There is a very close correlation between the development of the gonads and their ducts and the presence of the mental gland. Small males that have enlarged testes in the fall have small mental glands, but larger individuals in the spring and summer that have immature testes and vasa deferentia lack any trace of the gland.

Closely correlated with the development of the gonads is the presence of glands on the venter which appear as small, round, yellow or orange spots. These are especially numerous around the vent and are present in all males with mature gonads. Occasionally a reduced number of these "spots" may be found in females. Mittleman (1951: 109) used the presence of these "spots" as a diagnostic character in the description of a North Carolina subspecies of the slimy salamander, *P. g. chlorobryonis*. They occur, however, in *Plethodon glutinosus* throughout its range, as well as in males of other related species.

GROWTH AND MATURITY IN OTHER PARTS OF THE RANGE.—Bishop (1941: 227) measured 22 specimens of *P. g. glutinosus* from New York taken in October and November. He found that "a group of four juveniles varied in length from 58 to 64 mm. and perhaps represent the growth to the end of the first season. Another lot of eight varied from 74 to 98 mm." Juveniles with total lengths of from 58 to 64 mm. are found in Florida in June, about 5 months after the appearance of newly hatched young. This would correspond to the length of the growing season in New York from July through the summer and fall. Bishop (1927: 49) stated that "small specimens about one inch long have been found early in summer and females with large eggs in the body have been collected in December, so it is likely that the eggs are deposited in late winter or early spring in deep crevices of shale or rock where many individuals spend the winter." It is difficult to correlate snout–vent with total length because of the number of incomplete tails in various stages of regeneration, but specimens a year and a half old in Florida are generally longer than Bishop's second-year group which varied from 74 to 98 mm. in total length. If the classes Bishop defined are real, it would seem that *Plethodon glutinosus* grows more rapidly in Florida where there is a longer growing season; therefore, it must take at least 3 or more years for this species to reach maturity in the northern states, where it matures at a greater length. Pope and Pope (1949: 261) believed that in Virginia, "maturity is probably reached at the approximate age of three years." If this is correct, the females probably lay eggs at 4 years of age.

Cagle (1942: 177) reported that a large female *Plethodon glutinosus* collected in southern Illinois on March 15, 1939, contained eggs ready to be deposited. He did not give the size of the eggs, but this record indicates an egg-laying season similar to that which Bishop postulated for New York.

Pope and Pope (1949) concluded that the egg-laying season in the mountains of southwestern Virginia is quite extensive, occurring from June through September. They pointed out, however, that the egg-laying seasons in lowland New York and in the Virginia mountains might be expected to coincide. The above writers based their idea of an extensive egg-laying season on the fact that they collected a "spent" female in late June and an "unspent" female in mid-August. Their "spent" females were, however, in quite a different condition from those found in Florida in that their oviducts were not swollen and convoluted. Pope and Pope assumed that the oviducts had returned to normal size previous to collection, since *P. glutinosus* is known to guard its eggs and none was found with eggs. It should be emphasized that all 11 "unspent" females examined by these authors were collected in August and all five adult, "spent" females were found in June and July. If, as the summer progressed, more and more females were laying eggs, the opposite situation would be expected. Their sample, however, was a small one.

As pointed out by Gordon (1953: 57) the Popes' "unspent" females average larger (actually by 4.7 mm.) than the "spent" females.

If the standard error of the difference in the size between the two groups is calculated, it is found that t is equal to 2.56 and, therefore, the probability that these samples ("spent" and "unspent") were drawn from the same size population is 0.01. It is quite possible that two different size groups are represented, the larger being mature and the smaller immature. The condition of the oviducts also supports this view. Moreover, Pope and Pope did not give the size of the large yolk-laden eggs of the "unspent" specimens.

The series of 125 specimens that the Popes studied were examined by the writer. The group of 11 specimens that they described as having large yolk-laden eggs and swollen oviducts, actually have ovarian eggs ranging from 1 to 3 mm. in diameter. This is the size of the ovarian eggs of Florida specimens in June, some 2 to 3 months before the eggs are laid. Of the 12 females that the Popes considered to be "spent," two have large developing yolk-laden eggs, but, unlike the eleven other unspent individuals, do not have swollen and convoluted oviducts. Since there is much variation in the time of enlargement of oviducts in Florida specimens, it is not surprising that a few of the Virginia series lag behind the others in this respect. The two with large yolk-laden eggs should be added to the unspent group. Of the remaining 10 "spent" females, five are definitely immature with small eggs less than 1 mm. in diameter and with thin straight oviducts. These five, the smallest that Pope and Pope considered mature, have the following snout–vent lengths after 6 years in preservative: 58, 59, 59, 59 and 62 mm. The other five have ovarian eggs ranging from 1 to 1.5 mm. in diameter and small to medium-sized oviducts. It is probable that the ova of these latter five individuals were also maturing.

In 1953, Miss Marjorie Briggs collected 11 specimens of *P. glutinosus* near Mountain Lake, Giles Co., Virginia, between July 19 and August 9. This series, now in the Florida State Museum, contains a 65-mm. female with large ovarian eggs 2 mm. in diameter and large convoluted oviducts. A 59-mm. female is immature. In three adult males examined, spermatozoa were present in the testes of two and a few were present in the vas deferens of one of these. The third male had no spermatozoa present in either testis or vas deferens. Possibly the sex cells had degenerated in the latter, and the other two were in the condition that Florida individuals are in during late December or January, when the spermatozoa are beginning to move to the vasa deferentia from the testes. The gonads and ducts of the mature males collected by the Popes in 1948 were also examined and found to have medium to large testes and small to medium vasa deferentia. The external appearance of the gonads in these specimens is similar to that in the three individuals, mentioned above, taken during the summer of 1953. Since all except one of the Popes' males have small vasa deferentia, which in Florida specimens are devoid of sperm, it is difficult to explain the occurrence of the courtship dance observed at Mountain Lake Biological Station on the evening of August 19, 1949 (Pope, 1950: 96). However, the one exception was a 63-mm. male from Poor Mountain, a few miles southeast of Roanoke, Virginia, on August 19, 1948. Since all of the other males collected by the Popes were not yet in breeding condition, most courtship and mating activity must occur later in the year, as it does farther north. Bishop (1941: 224) believed that the mating season is in the fall because New York males lacked sperm in the vas deferens from May through August, but in those taken in October this structure was large and packed with sperm. Evidently most Virginia males are in a similar stage of the reproductive cycle as New York males during the summer. Humphrey (1925: 148) stated that in New York the extrusion of spermatozoa from the testes occurs in the fall. Evidence presented above indicates that this begins in late December in Florida. Burger (1937: 467) believed that meiotic divisions for the production of spermatozoa in *P. glutinosus* in New Jersey and Pennsylvania begin in April. In Florida they apparently begin in late summer.

The females that Pope and Pope (1949) considered ready to lay eggs in August would probably not have laid eggs for another 2 or 3 months (i.e., in October or November at the earliest) because of the small size of the ovarian eggs. The evidence available, then, indicates that *P. glutinosus* may deposit eggs in the mountains of Virginia at the same time it does in New York, during the late winter or early spring (since it presumably hibernates during

the winter). This would explain the fact that the young-of-the-year that Pope and Pope collected during the summer are approximately the size of five-month-old Florida specimens. This would correspond to the hypothetical late winter egg-laying of the Virginia population, suggested above.

Although the Popes' series of juveniles support the above hypothesis of winter or early spring egg-laying in the Virginia population, the one record of eggs for this region is Fowler's (1940: 133) discovery of a batch accompanied by an adult, on June 3, 1938, at Ice Mountain, Hampshire Co., West Virginia. Mr. Fowler informed me that these eggs, now apparently lost, contained large embryos. This is contrary to the assumption of Pope and Pope (1949: 257) that they were at an early stage of development. They could, therefore, have been laid in early April.

Hudson (1954: 69) reported that members of the Junior Zoological Society of Philadelphia collected a *Plethodon glutinosus* with several eggs in a rotten log at Hart Scout Reservation, Montgomery Co., Pennsylvania, on July 4, 1940. The finding of eggs of this species in the summer in Pennsylvania is evidence for an extensive egg-laying season in the northern states. However, the identification of these eggs should be confirmed, since they were secured during the laying season of *Plethodon cinereus* and this species often is found in the same logs with *P. glutinosus*.

Noble and Marshall (1929) found two egg clutches of the slimy salamander in Arkansas caves on August 17 and September 3, 1928, during the same season eggs are laid in Florida. Burt (1935: 312) found an individual 28 mm. in total length in Arkansas in early June, 1934. If egg-laying occurs in August in Arkansas, the young might be expected to be much greater than 28 mm. by the following June. The newly hatched specimen reported by Burt apparently appeared at a time indicating an egg-laying season similar to that which occurs in the northeastern portion of the range of this species. Because of such conflicting reports, detailed studies are needed from other parts of the range before direct comparisons can be made with the life history in Florida. It is not impossible that the egg-laying season in other parts of the range is of more extended duration or may even vary from year to year, depending on environmental conditions.

The writer has examined a few specimens of *Plethodon glutinosus* from other areas in the southeastern states which would indicate the reproductive cycle is similar to that in Florida. For example, two large females were collected on August 23, 1952, in DeKalb Co., Georgia (in the Piedmont Physiographic province), one of which was recently spent, and the other contained very large ovarian eggs, 5 mm. in diameter, obviously ready to be deposited. In addition, several juvenile specimens have been examined which were taken during the winter months in several southeastern states. These individuals show that the young-of-the-year are within the narrow limits of the size range of Florida specimens taken during the same months. Newly hatched young have been examined from Fulton Co., Georgia (an 18-mm. specimen collected December 26, 1952); Harrison Co., Mississippi (a 17-mm. specimen collected December 22, 1953); and Geneva Co., Alabama (two specimens measuring 22 and 24 mm. collected January 29, 1952). Other juveniles from Louisiana, Georgia, South Carolina and North Carolina taken in March and April are within the size range of juveniles in Florida during these months. Indications are, then, that the life history of this species in other southeastern coastal plain states is similar to that in Florida. Two records from DeKalb and Fulton counties, Georgia, in the adjacent Piedmont Physiographic province indicate that the life history also corresponds closely with *P. glutinosus* in Florida.

Data from other regions do not as yet clearly indicate whether or not the egg-laying season, in late winter or early spring in the northern states and in late summer in the southeast, is clinal in its seasonal variation from north to south. An abrupt latitudinal change would constitute an important isolating mechánism between the northern and the southern populations.

Growth and Movement of Marked Specimens

Sixty-eight salamanders of all size groups were marked by toe-clipping and each individual was immediately released at the point of capture. Any log under which a salamander

was discovered was always replaced in its original position. The sixty-eight individuals were marked and released at four different localities during the period from June 22, 1952, to February 8, 1953, and 15 of them were recaptured, some more than once. One purpose of marking and releasing was to determine the actual increase in length for comparison with the corresponding increase in the samples collected each month. Another purpose was to ascertain whether individuals of the size group known to be young of the year were still immature the following year when 2 years old. Limited data have been obtained on these two points, but the 24 recaptures have, in addition, revealed interesting information on the movements of this terrestrial salamander.

GROWTH AND MATURITY.—A 29-mm. female, marked on August 12, 1952, had the same snout–vent length on September 9, 1952, but when recaptured on April 5, 1953, had increased 14 mm. Its total length increased from 59 mm. on August 12 to 90 mm. on April 5. At this time it was preserved and found to be immature, with largest ovarian eggs 0.33 mm. in diameter. At the approximate age of 17 months it did not contain maturing eggs, thus supporting the conclusion reached earlier that females do not mature until they are 2 years old and, therefore, cannot lay eggs until they are three. This specimen was the smallest of its size group both in August, 1952, and in April, 1953 (Fig. 6).

A 38-mm. individual marked on October 12, 1952, and recaptured on December 29, 1952, 77 days later, had increased 3 mm. in snout–vent length and had regenerated 12 mm. of a partially lost tail. Another juvenile, also 38 mm. in length, taken on June 22, 1952, was recaptured on August 29, 1952, by which date it had increased only 1 mm. At some time during this 68-day period, it lost part of its tail and 4.5 mm. had regenerated. It has been noted that individuals with regenerated tails often do not possess the normal white spots on the regenerated portion. The pigment cells apparently take longer to regenerate than does the tail itself.

A 35-mm. male was marked on August 29, 1952, recaptured on September 9, 1952, and again on August 16, 1953, 352 days after its original capture. On this date it was preserved and found to be maturing. It had increased from 35 mm. in snout–vent length to 50 mm. and its total length increased from 73 to 103 mm., but the tip of the tail was lost. This specimen, almost certainly approaching 2 years of age, had not bred during the August breeding season, for its vasa deferentia were still tiny and unpigmented. Its testes were medium in size, but very light because of the lack of pigmentation. They were evidently beginning to mature. It had no mental gland, nor were the yellow ventral glands, present in mature males, evident. Thus, the two immature specimens recaptured in 1953, one of each sex, both very probably almost 2 years old, support the contention that the Florida population does not mature until the age of 2 years and therefore cannot breed until the age of three. It must be noted, however, that both these animals were smaller than the mean of their size group and the possibility exists that some of the larger males may mature a year earlier.

MOVEMENTS OF MARKED ANIMALS.—The twenty-four recaptures of marked individuals have given some data on the activity range of this species. All specimens marked were replaced under the same logs from which they were collected. The trauma of being captured, measured and marked, as well as having its habitat disturbed by the turning of the log, might increase the probability of a salamander's leaving the vicinity. Slimy salamanders can move comparatively rapidly, as evidenced by a specimen that moved 4 feet in the laboratory in 10 seconds. Another, also in the laboratory, moved 15 feet in 90 seconds. However, this was a greater distance than any individual was found from its point of release in the field (Table V). Such limited movement of marked individuals in the field seems to be rather convincing evidence that this salamander has a small activity range. This aspect of the problem should be further investigated in an area where individuals are more abundant. Grobman (1944: 281) suggested that the migration into glaciated territory north of the terminal moraine of the Wisconsin glaciation has been much slower in *Plethodon glutinosus* than in some other salamanders.

Only 15 of the 68 individuals marked have been recaptured. It is possible that part of the 53 not recaptured had moved to other areas or

TABLE V

MOVEMENTS OF RECAPTURED SPECIMENS OF *Plethodon glutinosus* MARKED DURING THE PERIOD FROM JUNE 22, 1952, TO AUGUST 16, 1953

The distance moved, if any, by specimens 261, 352 and the first recapture of 280, 283 and 295 were not recorded

Specimen No.	Date released	Date recaptured	Interval (days)	Distance from point of previous capture
257	June 22	Aug. 29	68	None
261	June 22	June 29	7	Same or adjacent log
280	Aug. 7	Sept. 3	27	Same or adjacent log
	Sept. 3	Sept. 5	2	None
283	Aug. 12	Sept. 9	28	Same or adjacent log
	Sept. 9	Apr. 5	208	2 feet
294	Aug. 29	Oct. 19	51	None
295	Aug. 29	Sept. 9	11	Adjacent log
	Sept. 9	Aug. 16	341	None
323	Sept. 28	Oct. 28	30	4 feet
327	Sept. 28	Feb. 8	133	None
352	Oct. 12	Dec. 29	77	Same general area
361	Oct. 19	Nov. 16	28	14½ feet
	Nov. 16	Feb. 8	84	6½ feet
365	Oct. 19	Oct. 28	9	1½ feet
	Oct. 28	Nov. 16	19	1½ feet (return to point of original capture)
379	Oct. 28	Nov. 16	19	2½ feet
388	Nov. 16	Dec. 6	20	None
389	Sept. 28	Oct. 19	21	None (attending eggs)
	Oct. 19	Oct. 28	9	None (attending eggs)
	Oct. 28	Nov. 16	19	None (eggs either hatched or desiccated)
	Nov. 16	Dec. 6	20	2 feet
	Dec. 6	May 8	153	2 feet (return to point of original capture-where eggs were found)
434	Dec. 31	Feb. 8	39	None

were dead, but it is likely that some were underground when the logs were investigated. Individuals often disappear rapidly into underground passageways beneath logs. Logs have been repeatedly turned between recaptures of an individual without finding it. Of interest in relation to the behavior of this species are two incidents that occurred on May 8, 1953. A juvenile was observed to retreat down a hole under a log the instant the log was turned. The ground was not disturbed and the log was replaced. Fifteen minutes later the log was turned again and a specimen of similar size was found in the same position. After this experience, I returned to a log where another juvenile had escaped a half hour previously. Here again was a specimen of similar size in the same position under the log. Apparently each individual had returned to its original position under the log after its replacement.

Neill (1952: 195) stated that, of 214 specimens of *Plethodon glutinosus grobmani* he collected in Florida, only one emitted a sound. Of the approximately 600 specimens that the writer collected during this study, only two made the squeaking sound described by Neill (*op. cit.*) and Mansueti (1941: 266). Both were adult females taken in Alachua County.

Piatt (1931: 29) reported an albino specimen of this species from Indiana. On March 16, 1953, I collected a 22-mm. albino at O'Leno State Park. It was similar to the specimen described by Piatt in that the venter lacked pigment and the pigmentation was much reduced on the dorsum and sides. In addition, the eyes lacked considerable pigment and appeared pink when held at the proper angle to the light.

DISCUSSION

The data presented indicate that *Plethodon glutinosus* in Florida has a relatively limited egg-laying season. No spent females were taken before August 29, and none with large ovarian eggs was taken after September 9. Although the egg-laying season may be slightly longer than the 11 days indicated, the fact that the young of the year are of such uniform size 2 months after hatching supports the view that the season is short.

It has not been possible to correlate the egg-laying season of *Plethodon glutinosus* in the various parts of its range for which information is available with either temperature or rainfall, but in both the northern states and in Florida the eggs appear to be laid just prior to the season of most favorable conditions for the growth of the young. In Florida where the hot summer reduces activity and growth, the eggs are deposited as the cooler weather approaches; in New York, where Bishop believed the eggs are laid in late winter or early spring, the warmer seasons are the more favorable for growth. The August egg-laying of this species in Arkansas does not appear to be so correlated, but caves are relatively uniform in temperature and humidity throughout the year.

Since all females over 56 mm. in length taken throughout the year have maturing eggs in their ovaries, it is assumed that adults lay eggs every year. One female, observed guarding a

clutch of eggs during the fall of 1952, was recaptured on May 8, 1953, at which time there were large maturing eggs 1.5 mm. in diameter in the ovaries (Table V, Specimen No. 389).

Although the eggs of *Plethodon cinereus* have been reported many times (see Bishop, 1941: 203–4 for references), it is strange that previous to this study only three clutches of *P. glutinosus* had been reported. Noble and Marshall (1929: 10) believed that the slimy salamander normally lays its eggs underground, as was indicated by those found in caves. Fowler (1940: 133) found eggs of this species inside a rotten stump in a cave region, and therefore believed that *P. glutinosus* normally lays its eggs in like situations. The finding of all five batches of eggs in Florida in and under rotting logs certainly confirms Fowler's belief. Probably eggs would be discovered in other areas of the range of this species if the exact egg-laying season were known. In New York and other northern states it is possible that, as Bishop (1927: 49) suggested, they deposit eggs deep below the surface of the ground before emergence from hibernation.

The necessity for making collections throughout the year in order to determine the details of the life history of a salamander may be emphasized. Noble (1931: 444) believed that it was merely necessary to make a large collection of an amphibian species and by determining the frequency modes of size classes and the size at which gonads are mature, the age of maturity could be determined. In this study, unless by chance the collection had been made during the breeding season, it is very probable that erroneous conclusions would have been reached. The information on the seasonal cycles of the gonads and their ducts presented here may be of aid in determining the life cycle of other closely related members of the genus *Plethodon* without such extensive monthly collections.

Summary

Plethodon glutinosus in northern peninsular Florida lays its eggs in late August and early September. The egg-laying season appears to be of short duration. Five clutches of eggs were discovered in the field, each accompanied by a female, on September 9, 1952, September 16, 1952, two on September 28, 1952, and one on October 17, 1953. The clutches contained 8, 11, 10, 7 and 9 eggs, respectively. Eggs from three of these five clutches hatched in the laboratory between October 10 and November 1, after an estimated incubation period of two months. All nests were found in or under rotting logs.

At hatching, ten of the young had snout–vent lengths of from 12 to 15 mm. (mean, 13.7 mm.) and total lengths of from 20 to 26 mm. (mean, 23.7 mm.). The weights of six of these specimens ranged between .08 and .09 g. The newly hatched young of this species are described for the first time. The hatchlings were not discovered in the field until the end of December in either 1951 or 1952. In their first 8 months the young almost double their length and increase their weight approximately six times. Activity is reduced during the summer and the eggs are laid at the beginning of a more favorable growing season. The weight does not increase during growth in proportion to the cube of the snout–vent length, but at a slightly lower rate.

The ovarian eggs of mature females enlarge slightly throughout the winter, but increase greatly from May to August. The testes of mature males enlarge during August and remain swollen until the following February; by May they are reduced in size. The vas deferens becomes large and convoluted and is packed with sperm from late February until the end of July or the beginning of August, when, presumably, courtship and mating take place. The maturation of the male germ cells is therefore begun a whole year before the breeding season.

Females do not mature until 2 years of age and therefore do not lay eggs until they are approaching the age of three. Some males, however, may have enlarged testes at the age of one year, but it is believed that this is usually an abortive sexual cycle which results in the degeneration of the spermatocytes formed, although in some individuals functional spermatozoa may be produced. Some males, at least, do not breed until three years of age.

Adult females are slightly larger than males. Adult Florida specimens average considerably less in length than the northern representatives of this species.

Movements of marked individuals in the

field suggest that they remain within a very limited activity range for at least several months.

Literature Cited

Allen, E. Ross, and Wilfred T. Neill. 1949. A new subspecies of salamander (genus *Plethodon*) from Florida and Georgia. *Herpetologica, 5 (6): 112–4.*

Allen, Morrow J. 1932. A survey of the amphibians and reptiles of Harrison County, Mississippi. *Amer. Mus. Nov., (542): 1–20.*

Bishop, Sherman C. 1927. The amphibians and reptiles of Allegany State Park. *New York State Mus. Handbook, (3): 5–141, figs. 1–59.*

———. 1941. The salamanders of New York. *New York State Mus. Bull., (324): 1–365, figs. 1–66.*

Burger, J. Wendell. 1937. The relation of germ cell degeneration to modification of the testicular structure of plethodontid salamanders. *Jour. Morph., 60: 459–87, figs. 1–9.*

Burt, Charles E. 1935. Further records of the ecology and distribution of amphibians and reptiles in the middle west. *Amer. Midl. Nat., 16 (3): 311–36.*

Cagle, Fred R. 1942. Herpetological fauna of Jackson and Union counties, Illinois. *Ibid., 28 (1): 164–200, figs. 1–15.*

Carr, Archie F., Jr. 1940. A contribution to the herpetology of Florida. *Univ. Florida Pub., Biol. Sci. Ser., 3 (1): 1–118.*

Dempster, W. T. 1930. The growth of larvae of *Ambystoma maculatum* under natural conditions. *Biol. Bull., 58 (2): 182–92, figs. 1–3.*

Fowler, James A. 1940. A note on the eggs of *Plethodon glutinosus*. Copeia, *(2): 133.*

Goin, Coleman J. 1947. Studies on the life history of *Eleutherodactylus ricordii planirostris* (Cope) in Florida. *Univ. Florida Pub., Biol. Sci. Ser., 4 (2): i–xi + 1–66, figs. 1–7, pls. 1–6.*

Gordon, Robert E. 1953. A population of Holbrook's salamander, *Eurycea longicauda guttolineata* (Holbrook). *Tulane Stud. Zool., 1 (4): 55–60, figs. 1–3.*

Grobman, Arnold B. 1944. The distribution of the salamanders of the genus *Plethodon* in eastern United States and Canada. *Ann. New York Acad. Sci., 45: 261–316, figs. 1–11.*

Hudson, Robert G. 1954. An annotated list of the reptiles and amphibians of the Unami Valley, Pennsylvania. *Herpetologica, 10 (1): 67–72.*

Humphrey, R. R. 1925. A modification of the urodele testis resulting from germ-cell degeneration. *Biol. Bull., 48: 145–65, figs. 1–9.*

Mansueti, Romeo. 1941. Sounds produced by the slimy salamander. Copeia, *(4): 266–7.*

Mittleman, Myron B. 1951. American caudata VII. Two new salamanders of the genus *Plethodon*. *Herpetologica 7 (3): 105–12.*

Neill, Wilfred T. 1952. Remarks on salamander voices. Copeia, *(3): 195–6.*

Noble, G. K. 1931. The biology of the amphibia. *McGraw-Hill, New York: i–xiii + 1–577, figs. 1–174.*

———, and Byron C. Marshall. 1929. The breeding habits of two salamanders. *Amer. Mus. Nov., (347): 1–12, figs. 1–4.*

Orton, Grace L. 1946. The size of the slimy salamander. Copeia, *(2): 107.*

Piatt, Jean. 1931. An albino salamander. *Ibid., (1): 29.*

Pope, Clifford H. 1950. A statistical and ecological study of the salamander *Plethodon yonahlossee*. *Bull. Chicago Acad. Sci., 9 (5): 79–106, figs. 1–5.*

———, and Sarah H. Pope. 1949. Notes on growth and reproduction of the slimy salamander *Plethodon glutinosus*. *Fieldiana Zool., 31 (29): 251–61, figs. 60–5.*

Simpson, George Gaylord, and Anne Roe. 1939. Quantitative zoology. *McGraw-Hill, New York: i–xvii + 1–414, figs. 1–54.*

Stebbins, Robert C. 1945. Water absorption in a terrestrial salamander. Copeia, *(1): 25–8, figs. 1–2.*

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A New Snake of the Genus *Leptotyphlops* from Michoacán, México

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Through the courtesy of Dr. H. W. Parker and Miss Alice G. C. Grandison I have been able to examine the specimens of reptiles and amphibians in the British Museum (Natural History) collected in the Balsas Basin area of Michoacán, México, by Dr. Hans Gadow in 1908. In this collection there is one specimen of *Leptotyphlops* which appears to be specifically distinct from any previously described members of the genus. The new species is named for Hans Gadow who pioneered herpetological collecting in Michoacán.

***Leptotyphlops gadowi*, sp. nov.**

Holotype.—British Museum (Natural History) No. 1914.1.28.123 from "above Apatzingan," Michoacán, México, collected by Hans Gadow in 1908. (The only available locality

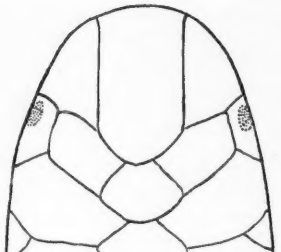

Fig. 1. Dorsal view of the head of the type specimen of *Leptotyphlops gadowi* (BMNH 1914.1.28.123).

data are "camp above Apatzingan, 2600 ft." Consequently the exact locality cannot be given. The altitude at Apatzingan is about 1640 ft.)

DIAGNOSIS.—A small species of *Leptotyphlops* probably most closely related to *L. phenops*, possessing an elongated rostral in broad contact with the supraoculars, one anterior upper labial, and narrow dark stripes on the venter.

DESCRIPTION OF HOLOTYPE.—Snout bluntly rounded; supraoculars large, rostral elongated and in broad contact with the supraoculars and prefrontal; ocular large and completely separating the two upper labials; six lower labials; nasal completely divided. Fourteen scale rows around the body; 10 scale rows around the tail; 235 scales from the rostral to the spine; 20 subcaudal scales. Total length 105 mm.; tail length 8 mm.; body diameter 2.3 mm.; tail length into total length 13.1 times; body diameter into total length 45.6 times.

The dorsal ground color is dark brown. Superimposed upon a cream colored venter are seven narrow longitudinal stripes, each centered on one of the seven rows of ventral scales. The lateral stripes extend anteriorly nearly to the head; the medio-lateral stripes extend successively less far anteriad, so that the median stripe extends only to within 25 mm. of the snout. On the posterior portion of the venter the ground color is dusky, and the stripes are obscured. The ventral surface of the tail is dark brown. The posterior fourth of the tail is a pale cream color. There are small white flecks on the snout that give it a grayish appearance. The lower parts of the upper labials, oculars, nasals, and rostral, plus the first, second, third, and sixth lower labials are heavily pigmented with brown. The chin and throat are also flecked with brown.

REMARKS.—*Leptotyphlops gadowi* differs from *L. phenops bakewelli* in having a lower scale count, the absence of dorsal stripes, and the presence of the ventral stripes. From *L. dugesi*, *L. maximus*, and *L. phenops phenops* it differs by having the elongated rostral in contact with the supraoculars. From *L. maximus* it also differs in having 10 instead of 12 rows of scales around the tail. The presence of only one anterior upper labial separates *L. gadowi* from *L. bressoni* and *L. myopticus*. The combination of the high subcaudal count (20), rostral in contact with the supraoculars, and the presence of the ventral stripes is sufficient to distinguish this species from all other known forms.

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A Discussion of the Deep-sea Eel Genus *Avocettinops*, with Notes on a Newly Discovered Specimen[1]

JAMES BÖHLKE AND FRANK S. CLIFF

AVOCETTINOPS, like *Cyema* and *Nessorhamphus*, is one of the most easily recognized genera of apodal fishes. Once seen, this fish with a bird-like head (Pl. I) and elongate tape-like body will neither be forgotten nor confused with any other eel. Its systematic position within the Apodes is just as definite and unmistakable, but the rank that *Avocettinops* should possess in the nomenclatural hierarchy of eels has been the subject of some discussion. This discussion has thus far, however, been largely confined to the principals in the issue, Bertin and Norman, the possessors of the only two known specimens of the genus.

HISTORICAL

While Roule and Bertin (1929: 30) wrote of their "DESCRIPTION D'AVOCETTINOPS SCHMIDTI NOV. GEN. NOV. SP.," and Norman (1939: 34) cited this same paper as the source of the original description of the fish, it appears to us that the name should date from Roule and Bertin (1924: 63). The diagnosis presented for their "Genre AVOCETTINOPS nov. gen." is certainly sufficiently detailed to separate it from all other apodal fishes and the new species name *schmidti* is presented in connection with it, thus apparently fulfilling the requirements for the publication of a new name as set forth by the International Commission on Zoological Nomenclature (Art. 25). However, the following circumstances concerning this description should be noted: (1) No type locality was given; (2) no specific description (as distinct from the generic description) was presented; and (3) the name of the new form was incorrectly stated (a lapsus or typographical error?) as "Espece AVOCETTINA SCHMIDTI nov. sp., 1 exemplaire."

In 1929, Roule and Bertin described the fish in more detail and this time stated that the description was based on a 510-mm. specimen collected on the Danish DANA-expeditions of 1920–22 from deep water off the north coast of Cuba. They considered it to be related to *Avocettina* Jordan and Davis, and integrated it into their new system for nemichthoid fishes as a distinct family. In the same paper, Roule and Bertin recognized a suborder Nemichthydiformes, containing the six families (the names presented without *-idae* endings[2]): Nemichthyidae, Cyematidae, Avocettinidae, Avocettinopsidae, Serrivomeridae and Gavialicipitidae. Their Avocettinopsidae was monotypic.

In 1932, Trewavas presented a revised system for the classification of the Apodes (revised from Regan's 1912 work), based on her studies of the osteologies of some rare deep-sea eels. On page 656 of this paper, as a footnote, she stated: "*Incertae sedis*. *Avocettinops schmidti* Roule & Bertin (*l. c.* p. 30, text-figs. 13, 14, pl. i., fig. 1). An elongate eel, with the snout produced into a short, soft proboscis and with no teeth in the jaws. Without anatomical characters the relationships of this eel cannot be determined. It bears resemblances to some of the Congridae, but is unique in having no teeth."

Bertin (1936a), in his classified bibliography, summed up the results of his previous researches. This quite naturally included a short synopsis of his work on *Avocettinops*. The annotated bibliographical section of his paper indicated that the new genus (*Avocettinops*) was described both in the 1924 and 1929 papers, thus shedding no further light on the problem.

A second specimen of *Avocettinops* was taken by the MABAHISS during the John Murray Expedition (1933–34) at Station 119, Zanzibar area; depth 1,207–1,463 meters; length of specimen 300 millimeters. This specimen was reported by Norman (1939: 34), who partially figured and described its osteology after clearing with potash and staining with alizarin. On the placement of *Avocettinops*, Norman remarked: "Roule and Bertin placed this genus in their suborder Nemichthydiformes, and erected a new family, Avocettinopsidae, for

[1] This study was done while Böhlke was Systematic Zoologist, U. S. Fish and Wildlife Service, Stanford University, and while Cliff was a student in the Natural History Museum at Stanford University.

[2] While Bertin did not use *-idae* endings on his family names in any of his works cited in this paper, they are here used in all instances, for reasons of clarity and in accordance with the International Rules.

its reception. However, comparing its cranial osteology with that of *Nemichthys*, *Avocettina*, *Labichthys* (Beebe & Crane, 1937, 'Zoologica', N. Y., XXII, pp. 353, 366, 375, text-figs. 6–8, 12–15, 19–22) and *Nematoprora* (Trewavas, 1932, *l.c.*, p. 648, pl. ii), all of the family Nemichthyidae, I find only comparatively small and unimportant differences. Apart from the unproduced, toothless jaws, *Avocettinops* seems to be a typical Nemichthyid, and the diagnosis of the family given by Beebe and Crane (1937, *l.c.*, p. 350) should be emended to allow of its inclusion."

In his "Classification of Fishes, both Recent and Fossil," Berg (1940) relegated the family Avocettinopsidae to *incertae sedis*.

Unaware of Norman's (1939) partial osteological description, Bertin (1942) once more took up the problem of *Avocettinops*. He here described the osteology of *Avocettinops schmidti* in some detail, using for material the cleared and stained holotype of the species, and believed his specimen still be be the only one in existence. In the second division of this paper, Bertin modified the classification of the sub-order as presented by Roule and Bertin (1929). He excluded the Serrivomeridae (and evidently also the Gavialicipitidae, although all mention of this family was there omitted) from the Nemichthyiformes, leaving in that sub-order the following four families: Cyemidae, Nemichthyidae, Avocettinidae and Avocettinopsidae. In the final portion of his paper, Bertin compared and contrasted the families Avocettinidae and Avocettinopsidae, and theorized briefly concerning the origin of *Avocettinops*. He considered *Avocettinops* to be a nemichthoid which has retained a great number of juvenile characters as an adult (neoteny), and considered the abyssal environment to be the causal factor. He believed the case of *Avocettinops* to represent a new confirmation of his theory (1936b; also 1949) of "... *rachitisme congénital* ...," which stated that in the great depths it is the absence of ultra-violet rays and the lack of balance between calcium and phosphorus that are responsible for the disturbances of ossification, disharmonies in growth and neotenic phenomena exhibited by abyssal fishes.

In 1944, Bertin published a "Notice Complementaire sur les Titres et Travaux ...," supplementary to the above 1936 paper. Additional notes on *Avocettinops*, taken from papers written since 1936, were there presented.

The final paper on *Avocettinops* to be noted is the 1947 work by Bertin, which compared the osteological descriptions by Norman (1939) and Bertin (1942). The discrepancies between the two were pointed out and weighed, and a new specific name suggested for Norman's specimen, should it ever prove to represent a distinct species.

Material

A single specimen, SU 47758, has been available to us for study. It is in good condition except that part of the tail is missing; the intact portion measures 365 mm.

The fish was taken with a tow-net on the Arcturus Oceanographic Expedition of the New York Zoological Society, at Station 113-T-4, 125 miles southeast of City Hall, New York City: 39° 15′ North Latitude, 72° 00′ West Longitude; July 25, 1925; 818 meters; one hour and 27 minute haul; 11:35 A.M.

Description

Body extremely elongated, ribbon-like, greatly compressed, its greatest depth evidently a bit anterior of mid-point of tail (judging from a comparison of our incomplete specimen with the dimensions of the complete fish that Roule and Bertin had, both specimens having a head length of 32 millimeters). Anus placed approximately one head length behind gill opening. Head typically nemichthoid but with an abbreviated bird-like beak. Branchial region of head long, with at least six branchiostegal rays curved upward to lend support to this sac-like region. The lowermost of these rays (in point of attachment) curves upward at its posterior end just as sharply as the preceding rays and is parallel with them all the way, thus being much more extensive and curved than the same ray on Bertin's specimen (1942, fig. 2, B). The two lower rays not evident on our specimen without dissection or staining.

Eyes very large, directed laterally, much nearer the dorsal profile than would appear from Pl. I. This figure is excellent except that the fish is tilted slightly toward the camera and more of the dorsal surface of the head shows than should from a strictly lateral view. Head evidently cartilaginous in a large part, cav-

Head of *Avocettinops schmidti*, SU 47758. Photo by Mr. Stanley Weitzman. Scale in inches.

ernous, flexible. Snout short, broad-based, pointed at its tip, with the shape of a triangle when viewed from above. Anterior nostril large, tubular, the tube directed forward and somewhat upward, directly in a line between middle of eye and tip of snout when viewed from the side, much nearer eye than tip of snout. Posterior nostril a rather large simple hole, above the level of the anterior nostril and immediately before the upper anterior margin of the eye. Lower jaw included. Angle of jaws extending posteriorly to slightly behind a vertical through midpoint of eye. Mouth completely toothless. The toothless condition of the jaws is perhaps a neotenic characteristic, since all other adult nemichthoids possess well-developed teeth; possibly the post-larval stage between loss of larval teeth and acquisition of adult teeth has here been preserved as the adult.

Gill-openings wide, semi-circular, the rounded portion facing anteriorly, not confluent below; openings nearly vertical but extending somewhat further back ventrally than dorsally; openings directly below pectoral fins.

FINS.—Bases of pectorals directed obliquely downward and back. Each pectoral fin with 15 rays. The pectoral rays are unusual, as mentioned by Roule and Bertin; they do not show segmentation and the two halves are very weakly, if at all, interconnected. The rays in the dorsal and anal fins are of the same type. While it is possible that rough handling by the net at the time of capture, the strength of the preservative or some other factor caused a break-down in the slight connection between these elements, it is also possible that the rays are not true adult teleostean fin rays. Rather, it may be as Bertin suggests (1942, p. 106) that the paired and non-articulated rays of *Avocettinops* correspond to the basal elements of normal rays; or, it may be that these rays are homologous to the actinotrichia of the larval fish fin and are a further indication of the neotenic origin of *Avocettinops*.

Dorsal fin long and rather low, its origin above midpoint of appressed pectoral fins. This is in strong contrast to the condition on Roule and Bertin's specimen where the dorsal fin begins on the head, in advance of both the pectoral insertion and the gill opening. In this same part of the body there exists what we believe to be an anomalous condition of the lateral line pore arrangement (to be discussed below), and we further believe that the factor which was responsible for the aberrant pore pattern might be the same as that which caused the different dorsal fin placement. While the dorsal fin is incomplete and no total count of its rays can be given, there are 20 rays in a median section of the fin equal to a head length. Anal fin beginning immediately behind anus.

LATERAL LINE SYSTEM.—There are 23 simple, rather large lateral line pores between the temporal pore on the head and a vertical with the anus, and 13 pores per head length at mid-body.

The lateral line pores on the head are arranged as follows: on each side, the supraorbital canal opens by three pores on the interorbital space just above the eye, and, continuing forward, is marked by three additional pores on either side of the snout; the posteriormost of the three snout pores lies directly above the rear margin of the anterior nostril, the middle one lies just above the front rim of the anterior nostril and the anteriormost lies approximately midway between tip of snout and fore margin of posterior nostril. There are ten pores in the suborbital branch; three along posterior margin of eye, four below eye and three in front of eye. Anteriorly, the canal passes between the fore nostril and the eye. The terminal pore lies between the nostrils and just above the level of the dorsal margin of the anterior nostril. The mandibular branch of the lateral line system on the head passes downward and slightly obliquely forward from the temporal pore to a point on a level with the lower margin of the pupil. At this point the canal bifurcates, the posterior branch terminating shortly in a single pore. The anterior branch opens by one pore directly behind the rictus, and, continuing forward, opens by five pores along the lower surface of each mandible (it is possible that another pore or pair of pores exists at the very tip of the lower jaw, but we doubt it; the extreme tip of the mandible is injured on our specimen). Two pores are present between the temporal pores.

There are a few remarks that should be made about the lateral line pore arrangement in the region between the temporal pores and the pectoral fins. Beginning at the level of the pectorals and proceeding forward, the lines on

either side of the body are at first parallel (the supposed normal state; see Roule and Bertin 1929, p. 31, fig. 14). However, the canal on the left side of the body soon terminates and that on the right side gives rise to a huge azygous median pore. From this large pore paired canals again proceed anteriorly.

The following tabulation is of measurements in millimeters of the present specimen of *Avocettinops schmidti*. The specimen is incomplete, with 365 mm. intact; however, the head length of SU 47758 is 32 mm. as was that of the 510-mm. holotype (see Roule and Bertin 1929, p. 32).

Length of head (tip of snout to upper end of gill opening)	32.0
Greatest depth of body	9.1
Width of body at anus (approximate)	2.5
Tip of snout to origin of dorsal fin	34.8
Tip of snout to middle of anus	66.5
Greatest width of gill opening	5.5
Tip of snout to angle of mouth	10.3
Length of snout	8.0
Width of bony interorbital	1.6
Diameter of eyeball	4.0
Width of head at posterior nostril	6.0
Tip of snout to anterior nostril	5.2
Tip of snout to posterior nostril	7.4
Tip of snout to tip of lower jaw (when mouth is closed)	1.9
Width of pectoral base (between bases of first and last rays)	3.1
Length of pectoral fin (longest ray)	7.9

General Remarks

Where they were comparable, the above measurements of SU 47758 were compared with those presented by Roule and Bertin (1929: 32) for the holotype of *A. schmidti*. Nearly all measurements, excepting those of the distance from tip of snout to dorsal origin, and greatest depth of body, are in fairly close accord in the two specimens. On the holotype, the dorsal fin originates on the head, in advance of the gill openings; on SU 47758, the dorsal begins distinctly behind bases of pectoral fins, on a vertical with longitudinal midpoint of longest pectoral fin ray when fin is appressed. This difference in fin placement would be of rather great importance were it not for the fact that the lateral line pore arrangement is aberrant in the same region. Perhaps these two characteristics are interrelated. At present, we are unable to offer any explanation for the difference in the greatest depth of body measurements between these two specimens (14.0 mm. on the holotype, 9.1 mm. on SU 47758).

The supporting skeleton of *Avocettinops* is cartilaginous in a large part, as it is (to a lesser degree) in others of the nemichthoids. In such a group of fishes, and based on individual cleared and stained specimens of each of the forms, it seems especially insecure to place too much significance on the "presence" or "absence" of particular skeletal elements. In order for these elements to be "present," they must be sufficiently ossified to take up enough stain to render them visible, and this is further influenced greatly by the type of staining mixture and time and method of staining. As an example, many of the eels are too weakly ossified in the tail region to retain any red coloring by the alizarin through the clearing process; in the same specimen where this occurs the vertical fin supports may come through the clearing process with an orange or pink color, and some of the cranial elements may be a deep red. Thus, in a single example many different degrees of ossification may be observed. The structure that is only slightly ossified and is colored a pink or orange color, is often very difficult to discern since the flesh of long or improperly preserved specimens retains a pink or orange color and may never become completely clear. It is certainly true that differences in time, degree and sequence of ossification could have great phylogenetic significance and could be excellent taxonomic characters; but these, like other morphological characteristics, are subject to variation within the species which cannot be evaluated by the use of single specimens. In a fish as degenerate as *Acocettinops*, it seems unwise to let the degree of ossification of skeletal parts be the sole distinction in erecting a new species as did Bertin (1947), especially since he compared descriptions of two very different sized specimens and actually examined only one of them. Bertin listed three distinctions between the two forms, but the first (that of a difference in origin of the branchiostegal rays) is apparently a difference of interpretation of which bone the two workers (Norman and Bertin) were seeing as the point of insertion for these rays. The second of the three distinctions of Bertin between his *Avocettinops normani* (new species) and *A. schmidti*, is that he noted no coracoids and five pectoral actinosts, whereas Norman mentioned a hyper- and a hypocoracoid and only four actinosts. This also may be

a matter of a difference of interpretation, since Norman (1939: 34) stated that his specimen was very badly damaged and the head nearly torn from the body; also, the anteriormost actinost, as pictured by Bertin (1942, fig. 1, C), is of quite different shape from the succeeding ones and may have been what Norman called a coracoid. The last of Bertin's three distinctions is that the sensory canal tubes of the frontal and pterotic are continuous in his specimen, but discontinuous in Norman's. As Bertin himself stated, this small difference perhaps results from the difference in age of the specimens.

On the basis of the above comparison and because of the very wide geographical range of many abyssal species, we consider *Avocettinops normani* to be a synonym of *A. schmidti*. The name *normani* was definitely proposed by Bertin (1947: 55), even though it was done very hesitantly; Bertin stated that if someone should, some day, specifically distinguish Norman's specimen, then he claimed for it the name of *Avocettinops normani*.

We have nothing further to say about Bertin's theory of congenital rachitism to explain the degeneracies exhibited by many abyssal fishes. However, we would agree with him that neoteny as a phylogenetic phenomenon has probably played a very important role in the evolution of a number of abyssal fishes (as well as many other fishes in many other environments), *Avocettinops* included. *Avocettinops* truly looks like a derivative, largely by neoteny, from a fish like *Avocettina*.

As a concluding remark we might note that for a great number of years, Bertin (and previously, also Roule) has been studying the nemichthoid eels, often in very great detail. As a result of such intensive investigation of this one group of eels, it appears that the differences between the various forms have been unduly exaggerated and the underlying similarities somewhat minimized. This has given rise to a classification which seems over-expanded. As examples, the Gavialicipitidae should be included in the Serrivomeridae (as was done by Berg, 1940), and all four of the remaining families (Nemichthidae, Cyemidae, Avocettinidae and Avocettinopsidae) should be placed in one, the Nemichthidae. The Avocettinidae and Avocettinopsidae, especially, should be combined. The groups into which Bertin has divided the nemichthoids thus far appear quite real, but the families seem unnecessarily multiplied.

Literature Cited

Beebe, W., and J. Crane. 1937. Deep-sea fishes of the Bermuda Oceanographic Expeditions. Family Nemichthyidae. *Zoologica (New York), 22 (4): 349–83, 22 text-figs.*

Berg, L. S. 1940. Classification of fishes, both recent and fossil. (In both Russian and English.) *Trav. Inst. Zool. Acad. Sci. URSS, 5 (2): 85–517, 190 text-figs.*

Bertin, L. 1936a. Titres et travaux scientifiques de M. Léon Bertin. *Paris: 1–87, 46 text-figs.*

———. 1936b. Contribution a l'éthologie des poissons abyssaux. *Bull. Mus. Hist. Nat. Paris, ser. 2, 8 (6): 506–11.*

———. 1942. Ostéologie du genre *Avocettinops* (apode abyssal) et révision du sous-ordre des Nemichthyiformes dont il fait partie. *Bull. Soc. Zool. France, 67: 101–11, 2 text-figs.*

———. 1944. Notice complémentaire sur les titres et travaux de Léon Bertin. Paris. (Pages unnumbered.)

———. 1947. Notules ichthyologiques. I. – Compléments sur le genre Avocettinops. *Bull. Soc. Zool. France, 72: 54–5.*

———. 1949. Systématique et écologie des poissons abyssaux. *Compt. Rend. XIII Congr. Intern. Zool., sect. 5 B, Rapports: 349–364.* (Also a two-page undated publication, evidently an abstract of this paper, with the same title.)

Norman, J. R. 1939. Fishes. The John Murray Expedition 1933–34, Scientific Reports, *7 (1): 1–116, 41 text-figs. London.*

Regan, C. T. 1912. The osteology and classification of the teleostean fishes of the order Apodes. *Ann. Mag. Nat. Hist., ser. 8, 10: 379–87, figs.*

Roule, L., and L. Bertin. 1924. Notice préliminaire sur la collection des Nemichthydés recueillie par l'Expédition du Dana (1921–1922), suivie de considérations sur la classification de cette section des poissons apodes. *Bull. Mus. Nat. Hist. Nat., 30: 61–7.*

———. 1929. Les poissons apodes appartenant au sous-ordre des Nemichthydiformes. *Danish "Dana"-Expeditions 1920–22, (4): 1–113, 9 pls., 57 text-figs.*

Trewavas, E. 1932. A contribution to the classification of the fishes of the order Apodes, based on the osteology of some rare eels. *Proc. Zool. Soc. London: 639–59, pls. 1–4, 9 text-figs.*

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Circulation of the Blood in the Respiratory Region of the Fishes *Labeo rohita* and *Ophicephalus striatus*

SHAILENDRA M. DAS AND DEVENDRA B. SAXENA

INTRODUCTION

A CONSTANT supply of fresh oxygen is as important to a fish as to ourselves, so that respiration may take place. The exchange of gases is essentially the same in a fish as in any higher vertebrate, the difference in the respiratory process being in the manner in which the life giving substance is obtained. Fishes ordinarily make use of oxygen contained in the air dissolved in water by means of special organs, the gills. Gills have their greatest development among the teleosts; and considering the respiratory area, they have been regarded as surpassing the lungs in efficiency. Gill efficiency, however, depends on the rate at which water passes over them. Gill respiration in a sense represents a stage of cutaneous respiration in which skin appendages have become specialized for exchange of gases. Gills are structures which increase the area and efficiency for gas transport across the respiratory surface. They show considerable modifications with change in oxygen environment, and frequently function in combination with other respiratory structures in the exchange of vital gases. The striking adaptability of fishes for the procurement of oxygen is exemplified by the many modifications which have evolved to alleviate limitations imposed by simple diffusion. Fishes have met similar respiratory problems (drying up of streams and tanks during April to June in India) in different ways.

A number of freshwater fishes are able to live out of water for a longer or shorter period, or can bury themselves and aestivate deep down in the mud. These adaptations lead to a number of accessory respiratory mechanisms to increase the efficiency or to supplement the action of gills. Many of these adaptations permit air-breathing, allowing some obviously aquatic teleosts to become temporary land dwellers. Aerial respiration provides an example of a fundamental change in the functioning of one of the main systems of the body and also in the resultant modifications of the correlated structures. The circulatory system, which is intimately connected with the respiratory organs, shows marked modifications with the elaboration of respiratory mechanisms.

The outstanding contributions on this subject are mainly by Taylor (1831), Hyrtl (1853), Day (1868), Dobson (1874), Das (1927, 1940), and Hora (1933), who showed that certain freshwater fishes have modified respiratory organs. Lately Thirmulachar (1946) and Majumdar (1951) have also worked out the anatomy and histology of the accessory respiratory organs of some Indian fishes. But to our knowledge, little or no attention has been paid by early or recent workers to the resultant modifications of the circulatory structures with the varied respiratory adaptations, except by Burne (1896), Lele (1932), Wu and Weichang (1946), Ghosh (1948), and Das and Saxena (1954).

We have selected the cyprinid *Labeo rohita* Hamilton-Buchanan, a species with typical aquatic respiratory organs, and have compared the circulation in this fish with that in the snakehead *Ophicephalus striatus* Bloch, which has an accessory air-breathing chamber, and have found remarkable modifications in the latter species. The present contribution shows for the first time in detail how the circulatory system of the respiratory region becomes modified and adapted to subserve respiration in an air-breathing fish.

MATERIAL AND METHODS

The fishes were procured in fresh condition from the fish markets of Kanpur and Lucknow and live specimens were also obtained from fishermen. The afferent vessels were injected through the ventral aorta by gum arabic carmine and gelatine carmine and were fixed in alcohol for a week and then dissected. Starch carmine mass was found unsatisfactory in these fishes. The injection was given while the heart was still beating to ensure proper circulation of the injection mass into the finest vessels. The efferent and venous systems were not injected, as the fish, after being narcotized and placed in 10 per cent formalin, showed

even the finer vessels distinctly, due to coagulation of blood in them.

The blood vessels were traced into and across the respiratory surfaces and accurate drawings were made from the dissections. These line drawings (Figs. 1–10) and one photograph (Pl. I) show the important features of our observations on the circulation of the blood in the respiratory region of *Labeo rohita* and *Ophicephalus striatus*.

Afferent Branchial System

Labeo rohita—The conus arteriosus continues as the ventral aorta (Fig. 1) which, after piercing the anterior wall of the pericardium, runs forward along the under surface of the floor of the pharynx in the mid-ventral line. It extends between the ventral ends of the fourth and first branchial arches, and terminates by dividing into the first pair of afferent branchial arteries (Af. b. 1st.). Just after piercing the pericardium, the ventral aorta gives rise to the fourth pair of afferent branchial arteries (Af. b. 4th.), in level with the ventral end of the fourth branchial arch. Between the fourth and first pairs of afferent branchial arteries, the second and third pairs of afferent branchial arteries (Af. b. 2nd.; Af. b. 3rd.) are given off in level with the ventral ends of the second and third branchial arches.

These afferent arteries curve backward and run for some distance along the under surface of the floor of the pharynx before traversing their corresponding branchial arches. On these arches they run along their grooved outer surfaces and lie externally to the efferent branchial arteries. During its course along the branchial arch, each branchial artery gives out a series of paired afferent lamellar arteries corresponding to the number of lamellae present.

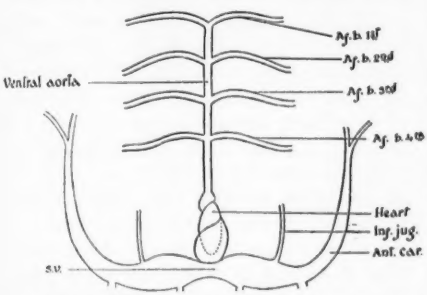


Fig. 1. Afferent and venous system in the respiratory region of *Labeo rohita*.

Af. b. 1st.–4th.—afferent branchial arteries first to fourth; Ant. car.—anterior cardinal; Inf. jug.—inferior jugular vein; s. v.—sinus venosus.

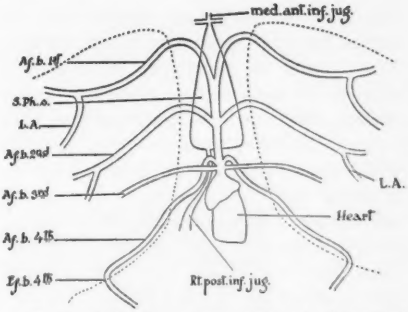


Fig. 2. Afferent system with sub-pharyngeal sinus in the respiratory region of *Ophicephalus striatus*.

Af. b. 1st.–4th.—first to fourth afferent branchial arteries; Ef. b. 4th.—fourth efferent branchial artery; L. A.—labyrinthine artery; med. ant. inf. jug.—median anterior inferior jugular vein; Rt. post. inf. jug.—right posterior inferior jugular vein; S. Ph. s.—sub-pharyngeal sinus.

Ophicephalus striatus.—After piercing the anterior wall of the pericardium, the ventral aorta runs forward along the under surface of the floor of the pharynx in the mid-ventral line (Fig. 2). It remains embedded most of its length in a venous sinus, lying on the floor of the anterior region of the pharynx, which we name the sub-pharyngeal sinus (S. Ph. s.). The ventral aorta extends from the ventral end of the third branchial arch up to the mid-distance between the first and second branchial arches, where it terminates by dividing into the first pair of afferent branchial arteries. Along its course in level with the ventral end of the second branchial arch, the ventral aorta gives off the second pair of afferent branchial arteries. Each second afferent artery (Fig. 3) divides immediately after its origin by a single common opening in the dorsal wall of the ventral aorta.

Just after piercing the pericardium in level with the ventral end of the third branchial arch, the ventral aorta gives off two pairs of afferent arteries. The anterior or third pair of arteries is in reality the fourth pair of afferent branchial arteries, which curves posteriorly and runs for a distance (Fig. 2; Pl. I)

dorsally to the third pair of afferent branchial arteries before traversing the fourth gill-arch. The posterior or fourth pair of arteries is actually the third pair of afferent branchial arteries, which runs nearly straight at right angles to the ventral aorta and passes ventrally to the fourth pair of afferent branchial arteries to supply the third gill-arch. A space is left between the third and fourth pair of afferent branchials (Pl. I; Fig. 3) since the fourth afferent loops back over and behind the third pair of afferent branchial arteries. The third and fourth pairs of afferent branchial arteries originate from the same opening on the roof of the ventral aorta. The third afferent branchial artery arises dorsally (Fig. 4) from the proximal part of the fourth afferent branchial artery. The third and fourth afferent branchial arteries of each side thus arise from a common root, and the two roots have one common opening. Thus, four arteries (the right and left third afferent branchial and the right and left fourth afferent branchial) originate by a single opening from the ventral aorta.

All these afferent arteries run for a distance along the ventral surface of the floor of the pharynx before traversing their corresponding branchial arches. During its course along the branchial arch, each afferent branchial artery gives off a series of afferent lamellar arteries

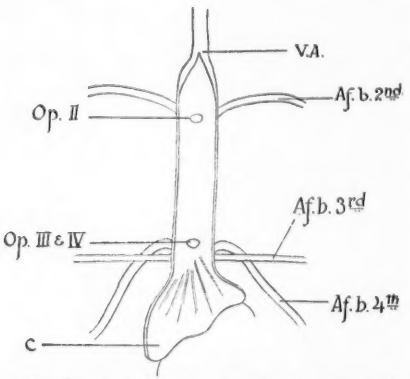


Fig. 3. Ventral aorta cut open to expose the opening of the second, third and fourth afferent arteries in *Ophicephalus striatus*.

Af. b. 2nd.-4th.—afferent branchial arteries second to fourth; c.—conus; Op. II, III & IV—opening of the second, third and fourth afferent arteries in the ventral aorta; V. A.—ventral aorta.

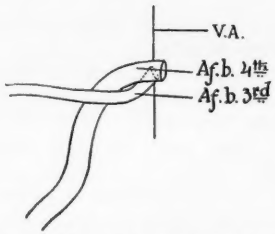


Fig. 4. Positions of the openings of the third and fourth afferent arteries in *Ophicephalus striatus*.

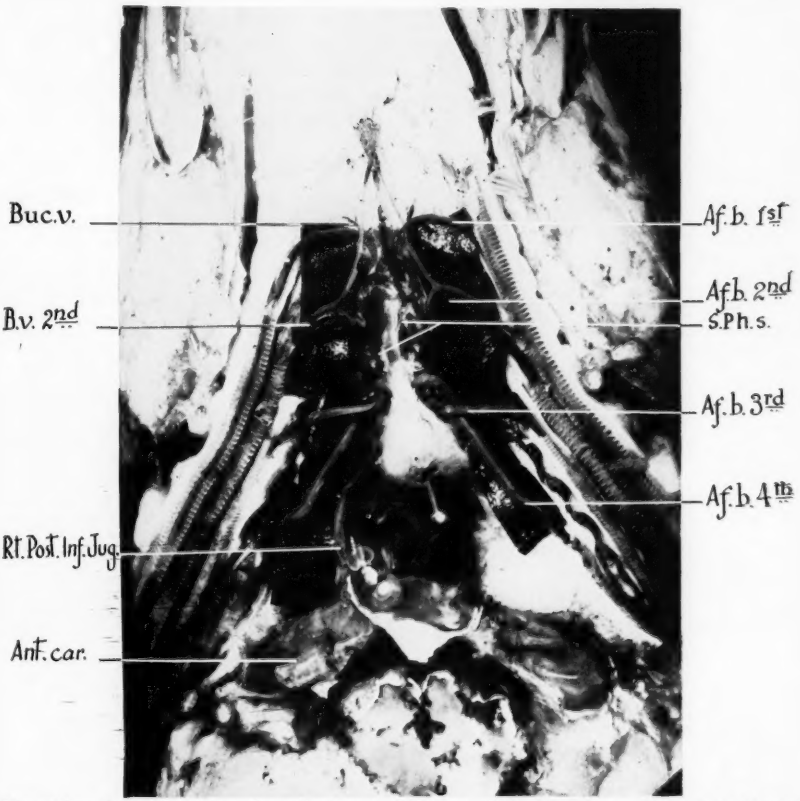
Af. b. 3rd. & 4th.—third and fourth afferent branchial arteries; V. A.—ventral aorta.

corresponding to the number of lamellae present.

The first pair of afferent arteries, besides giving branches to their gill filaments, are continued as large labyrinthine arteries (L. A., Fig. 2) passing to the anterior end of the air-chamber across the labyrinthine plate of the first epibranchial. The labyrinthine artery, after emerging from the gill, gives off a large branch, and both give off smaller branches. The second pair of afferent branchial arteries are continued beyond the gills as the second labyrinthine arteries. These divide into two, each of which branches out on the surface of the posterior part of the wall of the air-chamber.

Efferent Branchial System

Labeo rohita.—The blood, after being purified in each lamella and its secondary folds, is collected by the efferent lamellar vessel, which runs along the outer edge of each lamella and opens proximally into the efferent branchial artery. Each efferent branchial artery arises at the antero-ventral end of a gill-bearing branchial arch and runs all along the groove on the outer surface of its arch, lying internally to the afferent branchial artery. It leaves the arch at its postero-dorsal end. The first efferent branchial artery (Ef. b. 1st., Fig. 6), on leaving its branchial arch, curves around the second internal branchial cleft and runs posteriorly to meet the second efferent branchial artery (Ef. b. 2nd.), the two together forming the first supra-branchial artery (S. B. Ar. 1st.). The supra-branchial artery of each side runs posteriorly for a very short distance and unites with its fellow of the opposite side to form the anterior end of the dorsal aorta (D.



Disposition of the afferent arteries, sub-pharyngeal sinus and the sub-pharyngeal loop in *Ophicephalus striatus*.

Af. b. 1st.–4th.—afferent branchial arteries first to fourth; Ant. car.—anterior cardinal; B. v.—branchial vein; Buc. v.—buccal vein; Rt. Post. Inf. Jug.—right inferior jugular vein; S. Ph. s.—sub-pharyngeal sinus

A.), just at the level of about the middle of the long parasphenoid bone. The third efferent branchial artery (Ef. b. 3rd.), on leaving the postero-dorsal end of the third branchial arch, curves around the fourth internal branchial cleft, and runs posteriorly to meet the fourth efferent branchial artery (Ef. b. 4th.) of its own side, the two together forming the second supra-branchial artery (S. B. Ar. 2nd.). The second supra-branchial arteries of the two sides run posteriorly for a short distance until they reach the ventral surface of the dorsal aorta, into which each opens separately but close together in the region of the anterior part of the basioccipital bone, more than a centimeter behind the union of the first pair of supra-branchial arteries. The dorsal aorta now runs posteriorly through the drain-like channel in the basioccipital and emerges into the abdominal cavity.

Ophicephalus striatus.—After purification, the blood is collected by the efferent lamellar vessel, which runs along the outer edge of each lamella and opens proximally into the efferent branchial artery. The first and second efferent branchial arteries arise at the antero-ventral end of the gill-bearing first and second branchial arches and run along the groove on the outer surface of the arch, lying internally to the afferent branchial arteries. They leave the arches at the postero-dorsal ends and break up

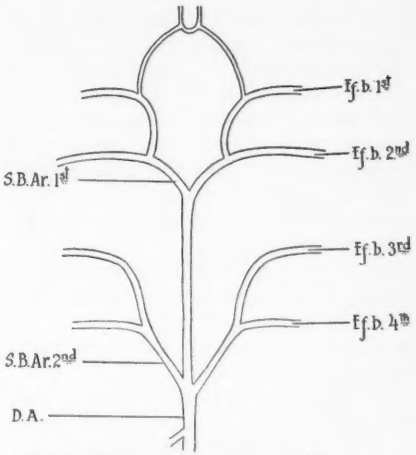


Fig. 6. Efferent system of *Labeo rohita.*

D. A.—dorsal aorta; Ef. b. 1st.-4th.—efferent branchial arteries first to fourth; S. B. Ar. 1st. & 2nd.—supra-branchial arteries first and second.

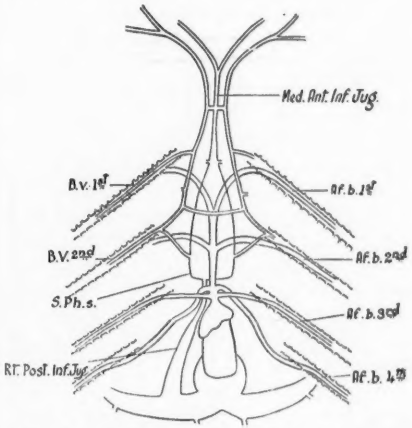


Fig. 5. Arrangement of afferent and venous system in the respiratory region of *Ophicephalus striatus.*

Af. b. 1st.-4th.—first to fourth afferent branchial arteries; B. v. 1st & 2nd.—first and second branchial veins; Med. Ant. Inf. Jug.—median anterior inferior jugular vein; Rt. Post. Inf. Jug—right posterior inferior jugular vein; S. Ph. s.—sub-pharyngeal sinus.

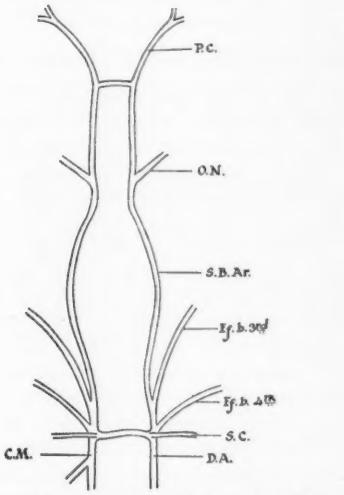


Fig. 7. Efferent system of *Ophicephalus striatus.*

C. M.—coeliaco-mesenteric artery; D. A.—dorsal aorta; Ef. b. 3rd. & 4th.—third and fourth efferent branchial arteries; O. N.—orbito-nasal artery; P. C.—posterior carotid artery; S. C.—sub-clavian artery; S. B. Ar.—supra-branchial artery.

into numerous small branches in the wall of the air-chamber. The third and fourth efferent branchial arteries (Fig. 7) are found to be in direct communication with the afferent branchial arteries of these two gills. After giving branches to the gill-filaments, they continue as large arteries to join the supra-branchial artery of their side.

The third efferent branchial artery joins the supra-branchial artery of its side a little in front of the transverse commissural artery joining the two supra-branchial arteries. The fourth efferent branchial arteries meet at the junction of the supra-branchial with the transverse commissural artery.

The supra-branchial artery of the left side, after giving off the left sub-clavian artery (S. C., Fig. 7) and being joined by the fourth efferent branchial artery, is continued posteriorly as the dorsal aorta. Similarly, after giving off the right sub-clavian artery and being joined by the fourth efferent branchial artery, the right supra-branchial is continued as the coeliaco-mesentric artery (C. M.).

Venous System in the Branchial Region

Labeo rohita.—The venous blood from the respiratory region, or the region in front of the heart, is collected by the paired anterior cardinal veins. The anterior cardinal system consists of a pair of large vessels, the anterior cardinal veins (Ant. car., Fig. 1), which receive a pair of smaller vessels, the inferior jugular veins (Inf. jug.). Each anterior cardinal vein begins by collecting blood from the eye and the adjacent parts, traversing the orbit, and then comes to lie on the ventral surface of the cranium above the dorsal extremities of the branchial arches. During its course it receives vessels that bring the blood from the brain and the outer parts of the head. On leaving the head it curves downwards to run along the outer surface of the posterior margin of the cleithrum, which it pierces, and enters the antero-ventral part of the pericardial cavity to open into the sinus venosus (s. v.) at its antero-lateral extremity. Before opening into the sinus venosus, each anterior cardinal receives the inferior jugular vein.

The inferior jugular vein of either side arises at the anterior end of the floor of the pharynx and runs backwards above the ventral aorta. It collects blood from the pharyngeal wall, enters the pericardial cavity (in which it runs along side of the heart), and finally opens into the anterior cardinal vein.

Ophicephalus striatus.—The venous blood from the respiratory region, or the region in front of the heart, is collected by the paired anterior cardinal veins. The anterior cardinal system consists of a pair of large vessels, the anterior cardinal veins (Fig. 8), which receive a single vessel on the right side, the inferior jugular vein. Each anterior cardinal vein begins by collecting blood from the eye and the adjacent parts, traverses the orbit, and then comes to lie on the ventral surface of the cranium in the air-chamber above the dorsal extremities of the branchial arches. During its course it receives vessels bringing blood from the brain and other parts of the head.

While passing through the air-chamber, the anterior cardinal of each side receives two supra-branchial veins or "pulmonary veins" (Pul. I, II), which have been formed by smaller vessels collecting blood from the air-chamber. On leaving the head, the anterior cardinal curves downward to run along the outer surface of the posterior part of the cleithrum, pierces and enters the antero-ventral part of the pericardial cavity, and opens into the sinus venosus at its antero-lateral extremity. Before opening into the sinus venosus, the right anterior cardinal receives the right posterior inferior jugular vein (Rt. Post. Inf. Jug., Fig. 8). The buccal vein (Buc. v.) of each side arises at the anterior end of the floor of the buccal cavity, being formed by a large number of smaller veins from the floor; these two veins join to form a single median anterior inferior jugular vein (Med. Ant. Inf. Jug.).The median anterior inferior jugular vein runs backwards and receives, at the level of the ventral end of the first branchial arch, the anterior pair of pharyngeal veins (Ph. v. I). The anterior pair of pharyngeal veins are formed by a number of smaller veins arising from the anterior region of the floor of the pharynx. Immediately posterior to it the median anterior inferior jugular vein enlarges to form a sinus—the sub-pharyngeal sinus (inferior jugular sinus)—which is median in position and extends in between the ventral ends of the first and third branchial arches. On each side the sinus receives one pos-

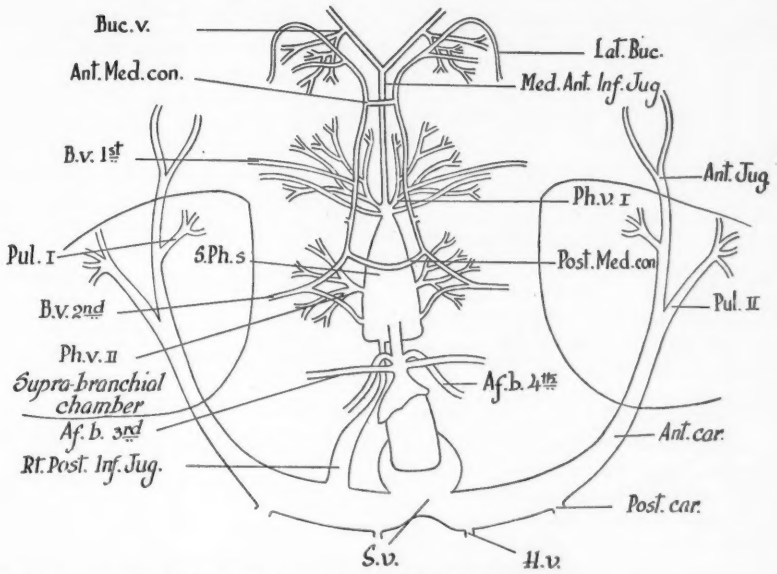


Fig. 8. Venous system in the respiratory region of *Ophicephalus striatus*.

Af. b. 3rd. & 4th.—third and fourth afferent branchial arteries; Ant. car.—anterior cardinal; Ant. Jug.—anterior jugular vein; Ant. Med. con.—anterior median connection; B. v. 1st. & 2nd.—first and second branchial veins; Buc. v.—buccal veins; H. v.—hepatic vein; Lat. Buc.—lateral buccal vein; Med. Ant. Inf. Jug.—median anterior inferior jugular vein; Ph. v. I & II—first and second pharyngeal veins; Pul. I & II—first and second supra-branchial vein ("pulmonary"); Post. Med. con.—posterior median connection; Post. car.—posterior cardinal; Rt. Post. Inf. Jug.—right posterior inferior jugular vein; S. Ph. s.—sub-pharyngeal sinus; S. v.—sinus venosus.

terior pharyngeal vein (Ph. v. II), which collects blood from the floor of the pharynx in level with the second branchial arch. The sinus, narrower anteriorly and broader posteriorly, has the appearance of an inverted cone. The single right posterior inferior jugular vein, which is on the right side, arises from the posterior end of the right side of the sinus, runs backwards on the floor of the pharynx next to the heart, and finally opens into the right anterior cardinal vein. A pair of lateral buccal veins (Lat. Buc.), which collect the blood from the antero-lateral margin of the buccal cavity, run backwards on either side of the median anterior inferior jugular vein. In level with the ventral end of the first branchial arch, the lateral buccal vein receives the first branchial vein (B. v. 1st.) from the first gill-arch and finally opens into the right and left second branchial veins from the second gill-arch. The second pair of branchial veins (B. v. 2nd.) communicate, one on each side, directly with the subpharyngeal sinus. The lateral buccal veins of each side are also connected with each other by an anterior median connection (Ant. Med. con.) in the anterior region, and by a posterior median connection (Post. Med. con.) in the posterior region, in level with the ventral end of the second gill-arch, thus forming a complete loop, which we name the sub-pharyngeal venous loop.

Course of Circulation

Labeo rohita.—The deoxygenated blood collected in the heart through the anterior and posterior cardinals is sent for oxygenation to the gills through the four pairs of afferent branchial arteries arising from the ventral aorta. The oxygenated blood is collected by the efferent branchial arteries (Fig. 9) and is sent for circulation to the head and body.

Ophicephalus striatus.—The deoxygenated blood from the anterior region and also the oxygenated blood from the first two gills and the air-chamber is collected in the heart through

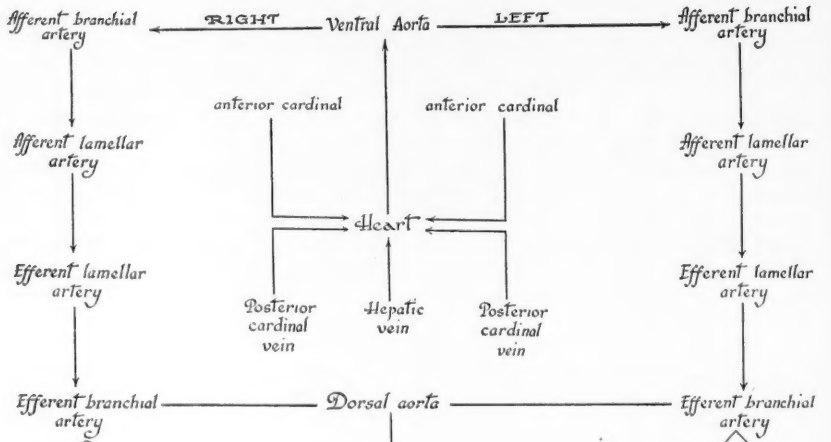


Fig. 9. Diagrammatic representation of the course of circulation in the respiratory region of *Labeo rohita*

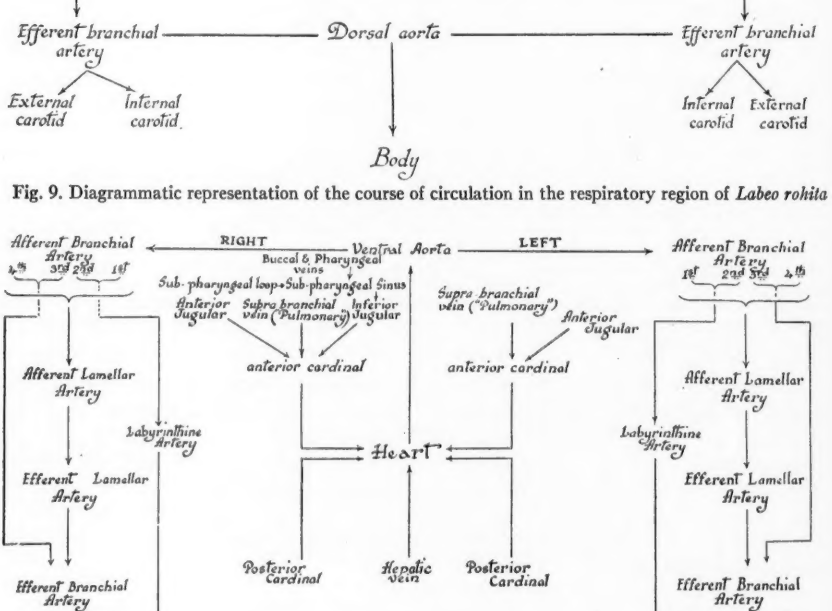


Fig. 10. Diagrammatic representation of the course of circulation in the respiratory region of *Ophicephalus striatus*.

the anterior cardinals. Thus it is seen that the first two gills of each side do not directly supply oxygenated blood to the rest of the body through the dorsal aorta (Fig. 10). The unoxygenated blood in the branchial filaments of the third and fourth gills, which are relatively very small, passes directly to the dorsal aorta for circulation to the head and body.

Discussion

Fish depend on free or dissolved oxygen to supply the necessary energy for their vital functions. When oxygen is used up at any point in the animal, the gas will diffuse from the surroundings towards that point. Diffusion is the main element in the respiration of all organisms but is usually supplemented by other transport mechanisms. Small organisms can generally obtain enough oxygen by diffusion from their surface without specialized circulatory or respiratory organs, while larger organisms have both circulatory and respiratory systems. Due to the adaptation of fishes to particular environment, the respiratory system and its blood supply have been modified accordingly.

The adaptive modifications in the chief blood vessels of the respiratory region have, however, not been satisfactorily worked out on any Indian fish, with a view to compare a purely aquatic and an aquatic-aerial species. Carter and Beadle (1931), in discussing the blood supply of the accessory respiratory organs, went so far as to say that the arterial supply of the organ is, as a rule, not of great interest from this point of view. They further added that if the organ is on the direct course of the branchial circulation (as in *Hypopomus*, *Clarias*, *Saccobranchus*, etc.), it is to be expected that no modification of either the main venous or arterial circulation would occur, and it is so. Lele (1932) did not go into the details of the circulation of blood in the respiratory region, but only traced the vessels to and from the air-chamber. In his sketch he shows the third and fourth afferent branchial arteries supplying the third and fourth gills consecutively, as is usual in other teleosts. But our observations show that the anterior of the two afferent loops above the posterior afferent, runs backward, and supplies the fourth gill-arch which has very few filaments and is the smallest gill. Ghosh (1948), working on the embryology of *Ophicephalus punctatus*, made similar but not identical observations on the roots of the afferent branchial arteries. The fourth afferent artery is thus longer and stouter than the third afferent artery. This observation is contrary to those of Carter and Beadle and Lele, who showed the usual teleostean arrangement. Further, although the second afferent branchial arteries of the two sides have one common opening into the ventral aorta, it is remarkable that we have found the third as well as the fourth afferent branchial arteries of the two sides originating from a single common aperture in the roof of the ventral aorta. This also appears to have escaped the notice of past workers.

The elaboration of the efferent branchial system, comprising the vessels arising from the cephalic ring, have not been traced in the past. The present contribution, therefore, shows the detailed structural modifications in the afferent and efferent branchial systems explainable on the basis of aerial respiration.

No satisfactory account of venous circulation in the respiratory region is obtainable from the literature. The complexity of the anterior cardinal branches in the air-chamber, which now contains the main veins bringing blood into the anterior cardinals, is initially worked out here. To our knowledge this is the first report of the formation of an accessory circulatory ring (the sub-pharyngeal venous loop), collecting blood from the floor of the buccal cavity and pharynx as well as from the first and second gills. The formation of a large sub-pharyngeal sinus (enlarged right inferior jugular sinus shifted to a median position), collecting blood both from the sub-pharyngeal loop and from the buccal, anterior and posterior pharyngeal veins, is also reported here for the first time. The significance of these elaborations appears to be twofold. Firstly, the veins originate from the floor of the buccal cavity and the pharynx by a large number of capillaries, thus collecting much blood from these regions. This blood, which is supplied to this region by the efferent system through the first and second efferents and also the labyrinthine arteries, is oxygenated in the capillaries lining the floor of the buccal cavity and the pharynx. Secondly, the circulation in the large groups of jaw muscle, which lie in this region, is also carried out by these vessels to some extent.

Das, Hyrtl, Lele, and Wu and Weichang have given detailed accounts of the structure and development of the organs that concern aerial respiration (and also the arterial circulation of the region to some extent) in *Ophicephalus*, but none of them has worked out these profound modifications in the circulatory sys-

TABLE I

A COMPARISON OF THE CIRCULATORY SYSTEM OF THE RESPIRATORY REGION IN *Labeo rohita* AND *Ophicephalus striatus*

System	*Labeo rohita*	*Ophicephalus striatus*
Afferent branchial	The ventral aorta gives off four pairs of afferent arteries in level with the ventral ends of the four gill-arches.	The ventral aorta gives out two pairs of afferent arteries in level with the ventral end of the third gill-arch, and one pair in level with the ventral end of the second gill-arch, and one pair by dividing into two at about the mid-distance between the ventral ends of the first and second gill-arches.
	The four afferent arteries supply the corresponding gill-arches.	The first and second afferent arteries supply the corresponding gill-arches; whereas with the next two, the anterior supplies the fourth and the posterior the third gill-arch.
Efferent branchial	The first and second efferent arteries from each side join to form the first supra-branchial artery. The two supra-branchials join to form the anterior end of the dorsal aorta, which is continued posteriorly, and receiving the second pair of supra-branchial arteries runs along the length of the body. The second pair of supra-branchial arteries is formed by the third and fourth efferent arteries on each side.	The first and second efferent arteries divide and subdivide in the air-chamber and do not communicate with the dorsal aorta. The third and fourth efferent arteries are continuations of the third and fourth afferent arteries, and meet the supra-branchial on each side separately. The supra-branchial of the left side, after giving off the left sub-clavian and being joined by the fourth efferent, is continued posteriorly as the dorsal aorta. Similarly, after giving off the right sub-clavian artery and being joined by the fourth efferent, the right supra-branchial is continued as the coeliaco-mesentric artery.
Venous	The anterior cardinals of both sides receive only the inferior jugular vein before entering the sinus venosus.	Both anterior cardinals also collect blood from the air-chamber by "pulmonary veins," but only the right anterior cardinal receives a single inferior jugular vein which brings blood from the sub-pharyngeal sinus and the sub-pharyngeal loop.
	No special branchial veins are present.	Two branchial veins from the first and second gill-arches join the lateral pharyngeal veins which form the loop.

tem of the respiratory region. When compared with a purely aquatic teleost such as *Labeo rohita*, these contrasts become all the more marked (Table I).

To our knowledge, this is the first time that a cephalic circle (in efferent system) has been demonstrated in *Labeo rohita*, although the general afferent and efferent systems have been worked out by Sarbahi (1938)[1]. We hope to show in a future contribution that, as there has been an evolution in the structure of the aerial respiratory organs in fishes, shown so admirably by Das (1940), there has been a profound modification in the circulation of the respiratory region as well, and thus these modifications show an evolution of equal importance to that shown by the organs themselves.

[1] Sarbahi, D. S. Anatomy and histology of the common Indian carp, *Labeo rohita* Ham.-Buch. Unpublished D.Sc. thesis, Lucknow University, 1938.

SUMMARY

The present paper gives a detailed account of the circulation of blood in the respiratory region of *Labeo rohita* Hamilton-Buchanan and *Ophicephalus striatus* Bloch. It reports the profound modifications that have occurred in the system to meet the requirements of the newly acquired air-breathing habit in *Ophicephalus striatus*.

The salient observations are: (1) the passage of the ventral aorta through the sub-pharyngeal

sinus; (2) the absence of the left inferior jugular; (3) the joint and single opening of the third and fourth afferent branchial arteries of both sides; (4) the specialized circulation in the branchial region due to the presence of the supra-branchial chamber; (5) the branching of the first and second efferent branchials into the air-chamber without joining the cephalic circle (or dorsal aorta); (6) the continuation of the third and fourth afferents as the third and fourth efferents respectively; (7) the presence of a sub-pharyngeal sinus and of a sub-pharyngeal loop; and (8) the presence of only the right inferior jugular vein. All these are profound modifications in *Ophicephalus* from the aquatic teleost plan and are worthy of note.

ACKNOWLEDGMENTS.—It gives us great pleasure to express our sincere thanks to Professor G. S. Thapar, Lucknow University, for working facilities and for helping us with references. We also wish to express our gratitude to Principal K. P. Bhatnagar and Professor K. K. Varma of D. A. V. College, Kanpur, for facilities given in the institution during the part of the work completed there by the junior author.

LITERATURE CITED

BURNE, R. H. 1896. On the aortic arch system of *Saccobranchus fossilis*. *Jour. Linn. Soc. London (Zool), 25: 48–56.*

CARTER, G. S., AND L. C. BEADLE. 1931. Respiratory adaptations in fishes. *Ibid., 37 (252): 327–68.*

DAS, B. K. 1927. The bionomics of certain air-breathing fishes of India, to-gether with an account of the development of their air-breathing organs. *Phil. Trans. Roy. Soc. London, Ser. B, 216 (433): 183–219.*

———. 1940. Nature and causes of evolution and adaptation of air-breathing fishes. *Proc. Indian Sci. Cong., Presidential Address, 27 (2): 215–60.*

DAS, S. M., AND D. B. SAXENA. 1954. Some new observations on the circulatory system of *Ophicephalus striatus* Bloch. (Actinopterygii; Percomorphi.). *Current Science, 23 (4): 127–8.*

DAY, FR. R. 1868. Observations on some freshwater fishes of India. *Proc. Zool. Soc. London: 274–88.*

DOBSON, G. E. 1874. Notes on the respiration of some species of Indian freshwater fishes. *Ibid.: 312–21.*

GHOSH, G. S. 1948. On the afferent branchial arteries in *Ophicephalus punctatus*. *Sci. and Culture: 293 pp.*

HORA, S. L. 1933. Respiration in fishes. *Jour. Bombay Nat. Hist. Soc., 36 (3): 538–60.*

HYRTL, J. 1853. Über das Labyrinth und die Aortenbogen der Gattung *Ophiocephalus*. *Sitz. Math. Nat. Cl. K. Akad. wiss. Wein., Bd. x.*

LELE, S. H. 1932. The circulation of blood in the air-breathing chambers of *Ophiocephalus punctatus* Bl. *Jour. Linn. Soc. London (Zool), 38 (257): 49–54.*

MAJUMDAR, N. N. 1951. Anatomy and histology of the palate of *Cirrhina mrigala* (Hamilton) with special reference to the papillae present on it together with comments on their possible respiratory function. *Jour. Zool. Soc. India, 3 (2): 255–65.*

TAYLOR, M. 1831. Respiratory organs and air-bladder of fishes of Ganges. *Edin. Jour. Sci., 5.*

THIRUMALCHAR, B. 1946. Observations on the aerial mode of respiration and correlated structural modifications of the respiratory organs in certain loaches (Cobitidinae). *Proc. Nat. Acad. Sci. India, 16 B (1): 6–12.*

WU, H. W., AND HSIAO-WEICHANG. 1946. On the arterial system of gill and supra-branchial cavities in *Ophicephalus argus*, with especial reference to the correlation with the bionomics of the fish. *Sinensia, 17 (1/6): 1–10.*

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Ichthyological Notes

THE OCCURRENCE OF THE TWO-PRONGED HATCHETFISH, *ARGYROPELECUS SLADENI*, IN BRITISH COLUMBIA.—A specimen of *Argyropelecus sladeni* was taken in a shrimp trawl at a depth of 41 fathoms on the north flats of the Sandheads off the mouth of the Fraser River on March 14, 1953, by Mr. E. McDermid. Mr. T. F. Rothery, fishery inspector, sent the specimen to the Pacific Biological Station for identification, and it is now in the collection of fishes at this Station.

One earlier specimen of *A. sladeni* taken from British Columbia waters was recorded as *A. olfersi* (Clemens and Wilby, 1949, Bull. Fish. Res. Bd. Canada, No. 68, p. 106, fig. 54). Dr. W. A. Clemens kindly forwarded the specimen to the author for examination and it was found to agree in every respect with the description of *A. sladeni*.

A. sladeni is closely related to *A. olfersi* but is readily distinguished from the latter by the preopercular spines. In *A. sladeni* the lower preopercular spine is straight, directed downward and a little

TABLE I

PROPORTIONAL MEASUREMENTS OF THE 2 SPECIMENS OF *A. Sladeni* FROM BRITISH COLUMBIA

	Specimen A, caught, 1953	Specimen B, caught, 1935
Standard length: the distance from the tip of the snout to the end of the vertebral column (base of midcaudal fin rays)	48.0 mm.	33.0 mm.
Height in standard length	1.74	1.65
Length of dorsal blade	6.8 mm.	5.5 mm.
Height of dorsal blade (broken in spec. A) in length of its base	<2.95	2.2
Lower margin of orbit to lower preopercular edge (lower base of upper preopercular spine), which is the relative depth of the cheeks, in standard length	5.21	4.72
Distance between the top of the transparent area in the last abdominal photophore and the top of transparent area in the first *post*-abdominal (preanal) photophore in standard length	6.40	6.21

outward, but not forward; the upper preopercular spine is of moderate size and is directed slightly outward and backward, its tip extending past the rear margin of the preopercular bone. In *A. olfersi* the lower preopercular spine points downward, and is curved slightly forward and outward; the upper spine is very small or absent, and its tip does not extend past the rear margin of the preopercle in adults.

Argyropelecus lychnus, another form very close to *A. sladeni*, has sometimes been recognized as a separate species, e.g., Parr (1937, Bull. Bing. Ocean. Coll., 3(7): 46 and 50, fig. 19). The specimens at hand agree with *A. sladeni* rather than with *A. lychnus* in the last two features given in Table I.

The body proportions and the position of the photophores of the two specimens (Table I) are in agreement with those given for *A. sladeni* by Regan (1908, Trans. Linn. Soc. London, 2nd Ser., Zool., 12(3): 218), Parr (*op. cit.*), and Schultz (1938, Proc. U. S. Nat. Mus., 86: 147).

The distribution of *A. sladeni* is extensive, having been reported from the Pacific Ocean (off Panama, Hawaii, the Philippine Islands, and southern Japan), from the north and south Atlantic, Antarctic and Indian Oceans.—W. E. BARRACLOUGH, *Fisheries Research Board of Canada, Pacific Biological Station, Nanaimo, British Columbia.*

PEAK HOURS OF PINK (*ONCORHYNCHUS GORBUSCHA*) AND CHUM (*O. KETA*) SALMON FRY MIGRATION FROM OLD TOM CREEK, S. E. ALASKA, 1952.

—In the course of a marine survival study conducted on Southeastern Alaska pink salmon by the Fish and Wildlife Service it was necessary to capture, without injury, considerable numbers of fry during their seaward migration. Since most downstream migrants confine their migration to the hours of darkness (Pritchard, 1944, Jour. Fish. Res. Bd. Canada, 6(3): 217–227), this experiment was designed to establish the period of the night during which the fry move in the greatest numbers. As chum salmon fry were migrating with the pinks, data also were obtained regarding their nocturnal migratory habits.

Old Tom Creek was used as the test stream to provide fry for the survival study as well as the material presented in this paper. It is situated on the east coast of Prince of Wales Island at a point midway between the entrance to Kasaan Bay and its head. Pink and chum salmon are the predominant spawners. They first enter the stream late in August reaching a spawning peak about September 20, with some remaining alive as late as October 30. Both species of fry emerge from the gravel in April, May and June and immediately begin their seaward migration. The pinks reach peak migration between May 15 and 30 while the chums peak a month later.

A series of fyke nets (a single unit of which is illustrated in Fig. 1) with mouth diameters of 12 inches and lengths of 3 feet were used to trap the fry as they moved downstream to the sea. These were placed in the stream near the upper limit of the intertidal zone suspended from ⅜ inch stainless steel cable by seven-foot lengths of nylon parachute shroud lines, two to a net.

After it was determined that most migrants followed a route located centrally within the greatest stream velocity, two nets were maintained in that area throughout the experiment. The nets were fished with the upper rims approximately 2 inches above the surface of the stream by shortening or lengthening the shroud lines in response to fluctuations in stream flow.

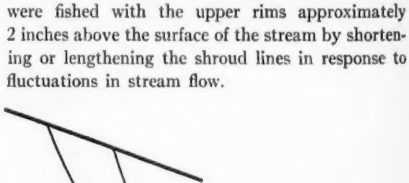


FIG. 1. Fyke net used in the experiment.

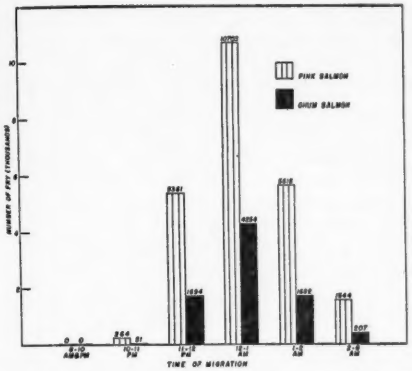


FIG. 2. Numbers of fry migrating by periods of the day.

The nets remained open in fishing positions from 8:00 a.m. to 10:00 p.m. each day. The catch then was emptied into a bucket and the nets were immediately reset. Between 10:00 p.m. and 2:00 a.m., the catch was removed hourly, but after 2:00 a.m. the nets fished continuously until the final count at 8:00 a.m.

The hourly catch of fry shown in Figure 2 is the summation of counts for seventeen days beginning June 8 and ending June 25. Significant migration began after 10:00 p.m. and small catches of both species were removed at 11:00 p.m. The catch at midnight showed an increased movement with the migration reaching a peak between midnight and 1:00 a.m. Between 1:00 a.m. to 2:00 a.m. the catch lessened, and at 2:00 a.m. the last hourly inspection was made. There was relatively little movement between 2:00 a.m. and 8:00 a.m.

Whereas Pritchard's work on McClinton Creek showed constant rates of seaward migration throughout the hours of darkness the migration on Old Tom exhibited a definite nightly peak which apparently was unaffected by changes in light intensity resulting from moonlight or overcast.—ALTON Y. ROPPEL, *U. S. Fish and Wildlife Service, Seattle 2, Washington.*

SILVER HAKE, *MERLUCCIUS BILINEARIS*, IN THE GULF OF ST. LAWRENCE.—There are no records in the literature of silver hake, *Merluccius bilinearis* (Mitchill), occurring in the Gulf of St. Lawrence. However, the following reports of fishing operations show that it is found there:

West Coast of Newfoundland, deep channels, 1954–55, occasional specimens, reported by W. Templeman;

NW Cape Breton Is., 8–15 ft., Feb. 15, 1954, one, L. R. Day;

NW Cape Breton Is., 50 fms., June 20, 1954, three, 31–45 cm., F. D. McCracken;

Magdalen Is., Aug., 1954, several, F. D. McCracken;

S of Le Fond George, June 25, 1952, three, E. G. Sollows;

Four mi. NW Pictou Is., Sept. 21, 1952, a number of small specs., total wt. 35 lbs., E. G. Sollows;

Northumberland Strait, 17–21 fms., July 7–28, 1954, fifteen, 33–58 cm., F. D. McCracken;

Off Miramichi Bay, June 15–16, 1950, two, S. N. Tibbo;

Head of Miramichi Bay, 9 ft., Dec. 24, 1954, one, 17 cm., R. A. McKenzie;

NE Miscou Is., 16–20 fms., Aug.–Sept., 1955, two, 34–36 cm., R. W. Fassold;

Mouth of Baie-des-Chaleurs, 44–48 fms., July–Aug., 1953, small numbers, A. Marcotte and Y. Jean;

Mouth of Baie-des-Chaleurs, 28–60 fms., July–Aug., 1954, small numbers, A. Marcotte and Y. Jean;

The disposition of the specimens listed above is unknown except for R. A. McKenzie's, which is in the Royal Ontario Museum of Zoology, Toronto, Ontario.

These records and the reported increase of this species on the Grand Banks off Newfoundland (Dr. J. L. Hart, letter of June 14, 1955) may be due in part to the general warming of the waters on the whole Canadian Atlantic coast since 1940 (Lauzier, 1954, Fish. Res. Bd., Prog. Rept. Atlantic, no. 58. note no. 124: 6–11) and the general northern shift of the species (Taylor and Graham, 1953, Abstract, Ann. Proc. Intern. Comm. NW. Atl. Fish., 3: 68).

In 1914–15 neither eggs nor larvae of the silver hake were taken within the Gulf of St. Lawrence by the Canadian Fisheries Expedition (Dannevig, 1919, Dept. Naval Service, Canadian Fish. Exped., 1914–15, pp. 1–74) and, though plankton tows in August 1954 yielded considerable numbers of silver hake larvae off Nova Scotia, none were found within the Gulf of St. Lawrence (L. R. Day, letter of May 6, 1955).

Though the foregoing previously unpublished records indicate that the silver hake is quite widespread in the Gulf of St. Lawrence, it does not spawn there nor as yet has it been reported from the northwest portion of the "Gulf" or in the St. Lawrence River (Dr. V. D. Vladykov, letter of March 2, 1955). Consequently, the species should still possibly be considered only as a "stray" in the area under consideration.

The assistance of those who contributed to the preparation of this account is gratefully acknowledged.—R. A. MCKENZIE, *Fisheries Research Board of Canada, Biological Station, St. Andrews, N. B. and* W. B. SCOTT, *Royal Ontario Museum of Zoology, Toronto, Ontario.*

BREEDING BEHAVIOR OF THE EGYPTIAN CICHLID FISH, *TILAPIA ZILLI*.—In the Far East and Middle East, attention has recently been focused on fishes of the genus *Tilapia* because they are prolific and provide a good source of proteins for man. Many plans for their introduction into other regions of the world where they are not native are now under consideration (Chimits, 1955, FAO Fisheries Bulletin, 8(1): 33). The great economic significance of *Tilapia* is appreciated most readily when it is realized that they provide 70 percent of the total inland fish production in Egypt. In other words, an average of about 36 million pounds of *Tilapia* is caught annually in this part of the Middle East.

Tilapia is found in the Nile and its tributaries as well as in the Nile Delta lakes. In Egypt there are several species of the genus but of these, only three are of primary economic importance: *Tilapia zilli* Gervais, *Tilapia nilotica* Linnaeus, and *Tilapia galilea* Artedi. All three species are extremely resilient, especially *T. zilli* which is euryhaline and can stand a salinity as high as 29 parts per thousand. Although the other two species can live in brackish water, they cannot survive in such highly saline water. A good example of the salinity tolerance of *T. zilli* was shown in Lake Qarun. This lake was originally fresh water but has recently become highly saline (salinity 29 ppt.). As a result of this abrupt change all the fresh-water fishes, including *T. nilotica* and *T. galilea*, disappeared. However, *T. zilli* remains and now provides the main fish supply from that lake.

There are two distinct breeding habits among the species of *Tilapia* in Egypt: some carry the eggs in their mouths during the whole period of development; others lay their eggs in nests and guard them until they hatch. It is generally agreed that *T. nilotica* and *T. galilea* have the first type of breeding habit. But there is no such general agreement as to *T. zilli* (Aronson, 1949, Zoologica, 34(3): 133–158). The remainder of this paper will therefore be concerned with the breeding behavior of this species.

Liebman (1933, Proc. Zool. Soc. London, 2(4): 885–888), working in Palestine, described *T. zilli* as a mouth breeder. However, I found that this was not so in Egypt on the basis of the following personal observations made during 1952 and 1953.

It is difficult to distinguish the sexes from their outward appearance, but paired *T. zilli* usually occupy a particular territory. Consequently, the choice and observation of fish couples were facilitated.

In experimental tanks, there was no courtship between male and female of a pair. They merely stood still in the corner of a tank either over or beside each other for 10 to 15 days, most often from May 20 to June 1. The couple then started digging in the sandy bottom of the tank and the male and female cooperated in carrying out this work. They picked up the particles of sand by mouth and typically excavated a concave type of nest of 8 to 10 inches in diameter and 2 to 3 inches deep, not unlike those of sunfishes of the family Centrarchidae. They repeated this nest building process until several nests were made.

Nest building is believed by many to be a necessary prelude to egg laying. It appears, though, that this process is not of vital importance because the female often leaves the nest and lays eggs elsewhere. It seems to me that nest building is a stimulus which only hastens egg laying and may indeed be a form of courtship.

As spawning time approached, the belly of both the male and female became pink in color; this was more pronounced in the male. The genital tubes of both sexes also became plainly visible to the observer. Next, the female started to press its pelvic fins against its genital tube, apparently forcing out the eggs. The eggs were deposited in chain-like links of about 20 at a time. The male immediately followed the female and fertilized the eggs by rubbing its genital tube against the egg chains. This process of egg laying and fertilization usually continued for 1½ to 2 hours. At the end of this period, typically, an oval disc, one egg thick, and approximately 127 by 153 millimeters in area was formed. The olive green eggs were so tightly packed together that they appeared hexagonal in form, but actually they were oval and measured 1.6 by 1.3 millimeters. The whole cluster, averaging about 4,600 eggs, was firmly fixed to the bottom by a sticky substance.

On the completion of spawning, the male and the female stood guard over their eggs, and at the same time the female started to fan the eggs with her fins.

At the end of two days, as hatching approached, the parents started to dig new holes in the sand. Hatching was completed in 74 hours from the time of egg laying. The newly hatched larvae soon started to move on the bottom from one hole to another.

Breder (1934, Zoologica, 18(1): 1–42) stated for another cichlid fish, *Aequidens latifrons*, that during this nest changing phase the young were carried by their parents, but in the case of *T. zilli*, the young themselves moved and the parents only performed guard duties over their moving young. Frequently, some of the young larvae lost their way in transit. Then the male or the female would dash to pick them up by mouth and return them to the nest. In all probability it is this type of parental care which has caused some scientists to think that *T. zilli* is a mouth breeder. This, however, is not true, because all developmental stages in this species take place outside the mouth.

Five days after hatching, the young began to move in schools. They were still guarded by their parents and would rise from time to time above the sandy bottom of the tank. This schooling behavior lasted for about 5 days until the yolk sacs were completely absorbed. Then, the close relationship with their parents terminated and the young began to swim very rapidly, scattering all over the tank.

Thirty days after egg laying, the same couple was ready to spawn again. The author was able to follow three broods and he found that egg laying always happened around 4:00 a.m.

The water temperatures at the three spawning periods were as follows: 1st brood, June 9, at 75°F; 2nd brood, July 2, at 80°F; 3rd brood, August 27, at 82°F. After the third brood, spawning stopped perhaps because the water temperature began to drop.

In conclusion, there is no foundation to the suggestion that the *T. zilli* is a mouth breeder.

There appears to be a regularity in the breeding cycle. The length of this cycle seems to reflect the period of time needed by the young to reach the independent stage.

It is tentatively concluded that there is a positive correlation between water temperature and the number of broods within the breeding season.—SALAH EL-ZARKA, *Department of Fisheries, School of Natural Resources, University of Michigan, Ann Arbor, Michigan.*

A PRELIMINARY REPORT ON THE GENETICS OF THE MEXICAN CAVE CHARACINS.—The first blind fish belonging to the family Characidae was found in a cave in San Luis Potosi, Mexico, in 1936, and described by Hubbs and Innes (1936, Occas. Papers Mus. Zool., Univ. Michigan, 342: 1–7) as a new genus and species: *Anoptichthys jordani*. Since then many experiments have been made with this species. Breder (1943, Trans. N. Y. Acad. Sci., Ser. 2, 5: 163–76) crossed the blind fish with its presumable ancestor *Astyanax mexicanus* (Filippi) and the phenotype of the F_1 hybrids was the same as that of the eyed and pigmented river fish, but no further genetical analysis was carried out at that time. My own experiments were started on March 8, 1954 at the American Museum of Natural History in the laboratories of the Department of Fishes and Aquatic Biology. This brief paper deals with some of the results of these experiments. The final conclusions will be published in extenso later.

I would like to express my thanks and appreciation to Dr. Breder for his kindness in giving me a place in his laboratory and supplying the necessary materials and for his many useful suggestions. Also, I want to thank my colleagues in this laboratory for their help and interest, and Prof. Kosswig, then of the University of Istanbul, for proposing this theme and encouraging me to begin this interesting research and for his criticisms. The work upon which this paper is based was supported for one year by Istanbul University and for four months by the Department of Fishes and Aquatic Biology of the American Museum. The experiments will continue partly in the laboratory of the Hydrobiological Institute at Istanbul and partly in the Zoological Institute of Istanbul University.

In these experiments the eyed river fish, *Astyanax mexicanus*, and three kinds of blind cave fishes were used. The blind fishes were collected from three different caves which are located in a single valley as follows:

1. The cave nearest to Rio Tampaon is La Cueva Chica, the type locality of *Anoptichthys jordani*.

2. Cueva de los Sabinos is about fifteen miles up the valley from La Cueva Chica. The fish from it were described by Alvarez (1947, Rev. de la Soc. Mexicana, 8: 215–19) as *Anoptichthys hubbsi*.

3. Cueva del Pachon is about 40 miles farther up this valley and the fish from it were named *A. antrobius* by Alvarez (1946, An. Escuela Nac. Cien. Biol., 4: 263–82).

Later, in another paper, the reasons will be given why it is believed that there is no valid justification for separating the cave fishes generically from *Astyanax* and specifically from one another.

Lüling (1954, Naturw. Rundsch. H. 5: 197–203) mentioned that the behavior of the river and cave fishes is different and that their crossing in the natural environment would be difficult and rare. This would have to assume the two types meeting in an illuminated environment which in itself would be most unlikely. He also noted that the eyed partner often killed the blind one. I originally attempted artificial fertilization but later abandoned it, as I found no difficulty in obtaining all kinds of crosses within two weeks using normal breeding methods. The essential problem may be solved choosing suitably sized fishes. In this case small *Astyanax* with intact eyes or larger ones which had been blinded spawned easily with large blind fish and there was no fighting. It was found that the optimal temperature for spawning was between 26° to 28°C. They will spawn at any season in aquaria, but generally they spawn more frequently between March and the first half of June.

Here, I want only to mention the kinds of crosses made and the general results. The development of the pigment system and the eye reduction in natural strains (Chica, Sabinos, Pachon, River) and in their hybrids (Chica × Sabinos, River × Chica, River × Sabinos, and River × Pachon) will be published later in the full report.

The embryos of all the blind fishes show rudi-

mentary eyes. Later these are enveloped with tissues in the much larger orbital cavities and are largely hidden. The optic cysts of the Pachon fishes disappear in this fashion at an earlier time than those of the Sabinos fishes while those of the latter are buried sooner than those of the Chica fishes. In this same series, from Pachon to Chica, these eye rudiments are found to be smaller in proportion to the time it takes them to become buried. None of the many young fish obtained in these experiments were without some trace of optic development in the embryonic stages. Pigment reduction follows a similar pattern, the pigment being least in Pachon and greatest in Chica.

In the F_1 of River × Chica, River × Sabinos and River × Pachon, all the hybrids obtained had smaller eyes than the river fish. The variation of the eye size is highest in the F_1 of River × Chica, less in River × Sabinos, and least in River × Pachon. The individual with the smallest eye was obtained from the crossing of River × Pachon and the largest one from the crossing of River × Chica. During the first three months some of the hybrids were very light, but later pigment developed in all of them. Nevertheless the first generations in all cases were not as dark as the River fishes. In the Sabinos × Chica cross only blind fish were obtained, some of them being darker than their parents.

In F_2 of River × Chica and River × Sabinos blind, small, medium and nearly full eyed fish were obtained which showed different degrees of pigmentation, ranging from nearly none to nearly full. At this writing the F_2 of River × Pachon has not been obtained. The numbers of blind and pigmentless fish are greater in the F_2 River × Sabinos than in River × Chica F_2. Another interesting fact is that the blind fish, which were obtained in F_2 of River × Sabinos crossing look more like Chica than they do look like Sabinos. A detailed study of their eye structure is required before this can be carried further.

At this time we may accept the following conclusions. 1. The fact that all the embryos of these cave fishes have some eye structure shows that even the fish in Cueva del Pachon, the cave farthest from the river, have some of the eye genes of their eyed ancestor, which is with certainty the river fish, *Astyanax*. 2. The diversity of the F_1 phenotypes in the same cross proves that the cave fishes used were not homozygous for the genes which are responsible for their blindness and their lack of pigmentation, but even individuals with the smallest number of degenerative genes are incapable of producing normal characters. 3. The inhabitants of the most remote cave (Pachon) have more degenerative genes than the members of the population in Sabinos while the degenerative genes are still fewer in the fishes from Chica, the cave nearest the river. 4. In F_2 blind pigmentless, blind pigmented, eyed pigmentless and eyed pigmented fish were obtained. The degree of pigmentation, and size of eyes show a high variability so that the number of degenerative genes cannot be estimated as yet. The recombination types which were obtained (eyed pigmentless and blind pigmented) show that the genes for rudimentation of each character are inherited independently.—PERIHAN SADOGLU, *Istanbul University, Zoological Institute and the American Museum of Natural History.*

OBSERVATIONS ON STRIPPING SMALL FISHES FOR EXPERIMENTAL PURPOSES.—There are many advantages in using stripped over naturally laid eggs for experimental work. Many fishes normally lay their eggs during a period of an hour or more, and the exact age of any egg can be ascertained only by careful observation during spawning. If the eggs are stripped and the sperm mixed with them, the time of fertilization of the individual eggs will at most vary a few minutes. Crosses can be made between forms which do not spawn (or live) under the same conditions, and between those that will not cross otherwise. In addition, experiments can be carried out with fishes which eat their own eggs. One disadvantage of stripping is the lowered rate of fertilization. Whereas over 90 percent of most naturally laid darter eggs are fertilized, our fertilization averages of similar stripped eggs usually range between 60 per cent and 80 per cent, dependent upon technique.

Mass stripping of eggs for artificial propagation of salmonoids has been carried out for years. An excellent review of the techniques is given in Davis (1953, Culture and Diseases of Game Fishes). Techniques for the propagation of bait cyprinids and catostomids by stripping are given by Surber (1940, Propagation of Minnows). Although bait fishes are often smaller than salmonoids, they average considerably larger than many of the forms we use.

Either freshly captured wild fish or individuals from laboratory stocks can be utilized. The former are easier to handle as the parental stocks do not have to be maintained, and one is forced to use this method if proper food and temperature for bringing fish into breeding condition are not available in the laboratory. Most of the males in the breeding populations we have studied release visible milt whenever tested, and even when no milt is macroscopically observed, fertilization may ensue. In small species such as the fountain darter, *Etheostoma fonticola* (Jordan and Gilbert), there often is so little milt that it is not macroscopically visible. In general, the same male can be used for three or four consecutive days. Ripe females are more difficult to obtain as only a certain percentage of

them may be ripe on a given day. For example, the greenthroat darter, *Etheostoma lepidum* (Baird and Girard), and the Rio Grande darter, *E. grahami* (Girard), will lay eggs once every four to ten days in the laboratory, depending on the temperature. To obtain as many eggs as possible from a single collection of freshly caught females, they should be checked for ripe eggs on the day captured and on the three or four following days. If food is provided, the checking period can be extended. Females should be used the day they ripen. When ripe female darters are held for two or three days, many of them spawn in the absence of a male; and when overripe females are used, poor hatches result. Wild-caught parents should be kept at the same temperature at which they were spawning in nature. If they are crowded, the water should be changed daily and aeration provided. Eggs of the orangethroat darter, *E. spectabile* Agassiz, from females held at the stream temperature near 60°F have hatched much better than eggs from females kept at temperatures in the low seventies.

Females are not harmed by careful checking for ripeness or by harvesting of ripe eggs. Ripe eggs are large, clear, adhesive, and flow with gentle pressure on the abdomen while unripe eggs are smaller, cloudy, and hard to squeeze out. Forcing out unripe eggs is to be avoided because it both injures the female and adds to the trash that should be removed from the hatching pan. Fortunately, unripe eggs are non-adhesive and can be washed free of the ripe eggs with a stream of water. Care must be taken, when testing a female, not to squeeze out the eggs before one is prepared to utilize them. In species such as the orangethroat and greenthroat darters, four or five eggs can be ejected with little danger of getting additional eggs, while half of the eggs of a logperch, *Percina caprodes* (Rafinesque), or redhorse shiner (*Notropis lutrensis* complex) can be lost while determining whether the female is ripe or not. Small or partially spawned females and members of species which lay few eggs should be tested with special care as the "test sample" may represent or approximate her total complement of eggs. In any event, tests should be made in the breeding pan with the ripe males readily available. The posterior part of the abdomen is noticeably distended in ripe females. Experience and careful observation permit one to select ripe females from a mixed stock readily. Careful observation of the ovipositor while gentle pressure is applied to the abdomen will help prevent both injury to the female and wasting many eggs. If it is clear, the female is usually ripe; if it is cloudy, the female is usually nearly ripe; and if it becomes pinkish, the female is not ripe and you are squeezing her too hard.

A superior method of obtaining ripe fish is to keep properly fed laboratory populations at spawning temperatures. As most of our stocks maintained in this manner are in spawning condition, the seasonal aspect of procuring ripe fish is removed and the same individual can be used in a number of control and hybridization experiments. For both darters and minnows the behavior of the males indicates the presence or absence of one or more ripe females in the tank. If one is present, several males in breeding color will be fighting among themselves and courting her. The female can be dipped out and stripped.

Although almost any container may be used for hatching, we have used only white enamel pans. If the enamel is intact, no harmful chemicals are given off and observations on the development of the eggs are easy. We use either 9″ x 15″ rectangular pans 2¼″ deep or circular pans 10″ in diameter and 4½″ deep. Rectangular pans waste less space; ones larger and deeper than those described above are preferable. Deeper pans give a greater buffer against sudden environmental change and the added height above the water surface reduces the number of fish that jump out. For darters with a long free-swimming stage, fewer individuals die in the deeper containers. Any pan should be cleaned thoroughly before using, especially if it is new, and rinsed with water of nearly the same temperature and dissolved chemicals as that in which the young are to be raised. If the experimental temperature differs widely from room temperature, the pan should be floated in water maintained at the experimental temperature. Excess water should be drained off. Davis (*op. cit.*) gives an account of the relative advantages of dry and wet stripping techniques. The prospective parents are then placed in the pan. The female is laid on her side and her abdomen is pressed gently. A gentle stroking pressure from the isthmus toward the urogenital aperture is best. If two workers are available, the male can be stripped at the same time. If not, he should be stripped immediately after the female. The male is held with two fingers on either side of the anterior part of the abdomen while the posterior abdomen is gently stroked. The milt runs over the anal fin which is used as a brush to spread the sperm over the eggs. Not only does this aid the fertilization but also it spreads the eggs over the pan. Care must be taken to get all eggs off the male after fertilization is completed. Moreover, a vigorous male may knock eggs into adjacent pans if the worker is not careful.

As noted above, varying degrees of pressure are required to expel the eggs. Fishes that apparently lay large numbers of eggs at one time require less pressure than the fountain darter, which usually lays a single egg at a time. Parental size may be related to the ease of egg removal as the fountain darter is the smallest species we have tested. However, we have noted no variation of ease of stripping

eggs between large and small females of a single species, and small female greenthroat and orangethroat darters are far easier to strip than the largest fountain darter females.

After the eggs and sperm have been together for a short period, excess milt, mucous, and unripe eggs should be rinsed out with the kind of water which will be used for the experimental conditions. (Fortunately all of the oviparous fishes with which we have worked have adhesive eggs.) The pan is then filled with water to the desired depth. Aeration should be provided as mortalities are higher without it. For the fishes from limestone regions, we add some rocks from the bottom of the parental habitats, as late embryos and young are very susceptible to adverse chemical content in the water.

The eggs from each female should be bunched to facilitate fertilization. However, they should be spread soon after fertilization as fungus more readily attacks bunched eggs. Darter eggs can be spread by the use of the anal fin of the male, a stream of water, or a feather. If eggs are not spread immediately after fertilization they should be separated as soon as the egg shell hardens. The shock of breaking the eggs loose causes unfertilized eggs to turn cloudy. All cloudy eggs (dead) should be removed with a pipette to prevent fouling the water. Freshly laid darter eggs are soft and may need up to 24 hours to harden before being broken loose. They should not be roughly treated just before hatching as the egg shell is now fragile and the fish may rupture out of the egg. Prematurely hatched young have a reduced survival rate. The darters with which we have worked do not have the "critical period" prior to pigmentation of the eyes at which time many other fishes are very susceptible to rough treatment. Davis (*op. cit.*) discussed treatment of eggs of several bait and game fishes. After hatching, the young are fed newly-hatched brine shrimp frequently. We add pond snails to clear up excess brine shrimp, and *Daphnia magna* to act as filters.

Our post-fertilization techniques for minnows differs from that used for darters. The eggs are so firmly attached to the tray almost as soon as they are squeezed from the female that attempts to dislodge them result in smashing half the eggs and low survival of the others. We add pond snails to clear up the dead eggs and larvae. Extensive groups of fungused eggs are removed with a pipette. As minnows feed on infusoria for some time before they eat brine shrimp, we do not add *Daphnia*, which eat infusoria.

The above techniques have been worked out in conjunction with research projects supported by the National Science Foundation and The University of Texas Research Institute.—KIRK STRAWN AND CLARK HUBBS, *Department of Zoology, The University of Texas, Austin 12, Texas.*

A RECORD OF THE LANCELET, *BRANCHIOSTOMA CARIBAEUM*, FROM THE STOMACH OF A STURGEON FROM THE GULF COAST OF ALABAMA.—The first lancelets known in the Gulf of Mexico west of Pensacola were collected in lower Aransas Bay, Texas, in 1948, and later identified by Dr. Gordon Gunter (Gunter and Knapp, 1951, Texas Jour. Sci., 3(1): 134–138 as *Branchiostoma caribaeum*. Hefley and Shoemaker (1952, Science, 115:48) recorded *Branchiostoma sp.* from several of the islands along the coasts of Louisiana and Mississippi.

On December 5, 1953, a sturgeon was captured in a commercial shrimp trawl off the coast of Alabama in the vicinity of Dauphin Island, and was identified in the field as *Acipenser sturio*. Examination of its stomach contents revealed nine lancelets referable to *B. caribaeum*. They varied in length from 28 to 45 mm. Although they were slightly digested, myotome and dorsal ray chamber counts were made possible by clearing in glycerin. The gonads were missing. The myotome count ranged from 55 to 60; the dorsal ray chambers averaged 301. These specimens constitute the first record of *Branchiostoma* from Alabama waters. They also represent the first report of lancelets in the diet of sturgeons.—HERBERT T. BOSCHUNG, JR. AND JACK C. MALLORY, *Department of Biology, University of Alabama, University, Alabama.*

ONSET OF SPAWNING ACTIVITIES OF THE SHALLOW WATER CISCO, *LEUCICHTHYS ARTEDI* (LeSueur), IN LAKE MENDOTA, WISCONSIN, RELATIVE TO WATER TEMPERATURES.—Cahn (1927, Ill. Biol. Monog., 11(1): 7–151) stated that the cisco in Lake Mendota begins to expel its eggs only after the temperature of the water has fallen to about 3.5°C. He reported that gravid females from Lake Mendota, held in the laboratory for several weeks, subsequent to the spawning season at temperatures above 4°C, expelled their eggs within a few minutes after the water had been cooled to 3.5°C. He concluded "that the temperature is the causal factor for egg production and that the critical temperature is needed before the eggs will be laid."

During recent years, observations at Lake Mendota indicate that the cisco generally arrive on the spawning grounds when the temperature drops to 5–6°C, but several days pass before egg-deposition begins. The extent of the delay is apparently determined by the course of temperatures because the spawning activities rise rapidly to a maximum when the temperature falls below 4°C. The maximum in 1950 occurred between December 2–5; in 1951, between November 23–28; in 1952, between December 2–6. During the autumn of 1953, however, the water remained warmer until

a later date than usual. Accordingly, egg-laying was initiated at a later date; the maximum occurred between December 9–11. But, at the cessation of spawning on December 11, the temperature of the water had not fallen below 4°C; it was 4.6°C. Fish had begun to arrive on the spawning grounds December 2, at which time the temperature of the water was 6.3°C. The first spent female was captured on December 7; the temperature was 5.4°C.

During each season, for a period of several days after the cessation of spawning in the lake, gravid females were retained in the laboratory at temperatures ranging mostly below 3.5°C. They did not expel their eggs.

The literature on white fishes in general (Coregoninae) indicates that the initiation of spawning activities is strongly linked with specific values of temperature, all of which are relatively low, and may differ from one region to another. (See Steinmann, 1950, Schweiz. Zeit. f. Hydro., 12: 109–189; Fabricius, 1949, Inst. Frshwtr. Research, Drottningholm, Ann. Rept., 31: 57–99; Wagler, 1941, Hndbch. der Binnenfischerei Mitteleur., 3: 370–501; Stone, 1938, Trns. Amer. Fish. Soc., 68: 234–45; Nümann, 1950, Archiv. f. Fischereiwiss. 3/4: 144–154.) Yet, Elster (1943, Reichsanstalt f. Film u. Bild in Wiss. u. Unterricht Hochschulfilm, c 405) stated that the Blaufelchen (*Coregonus wartmanni*) in Bodensee (Lake Constance) usually begins to spawn when the lake becomes isothermal at 7°C, which generally happens toward the end of November or the beginning of December. During unusually late autumns, the spawning season is delayed, but occurs before the middle of December even though the temperature may not have decreased to 7°C.

In Lake Mendota and Lake Constance and presumably in other lakes, egg-laying is initiated by a specific value of temperature provided this value obtains early in the season. If the arrival of this temperature is delayed, spawning is accordingly delayed, but not for an indefinite period. Rather, it occurs at a temperature higher than that which was thought to merit the term "critical".

Other stimuli that may act in conjunction with temperature in initiating the spawning activities of the cisco are unknown. One might suspect that day-length plays some role in the combined processes leading up to and including ovulation. Many widely distributed populations of whitefishes spawn at approximately the same dates as the cisco in Lake Mendota, but not at the same temperatures (see literature cited), indicating that day-length, or some other seasonal variable, acts as a determining factor. On the other hand, the work of Fabricius (*op. cit.*) on some populations in Sweden shows that day-length is not the critical determinant of the spawning season. The fish respond rather to the combined stimulus of suitable spawning beds and specific temperatures. He discussed one population which spawns in different parts of a confluent habitat in a chronological order corresponding to the order of occurrence of the specific temperature, thus spawning through a period of five months.

Judging from studies made on other whitefishes, the tendency for spawning to take place at a later date on those years when higher temperatures prevail suggests that it is an adaptation of survival value. The mortality rate for cisco embryos in the early stages of development is undoubtedly proportional to the temperature, as it is for *C. clupeaformis* (Price, 1940, Jour. Gen. Physiol., 23: 449–468) and for *C. wartmanni* (Nümann, *op. cit.*). Hence, the longer the females retain their eggs during the autumnal thermal recession, the greater is the chance that the eggs will be deposited at a more favorable temperature, e.g., near the so-called threshold value. Price (*op. cit.*) also stated that the eggs of *C. clupeaformis*, during the early stages of cleavage, are extremely sensitive to fluctuations in temperature. The potential magnitudes and velocities of thermal fluctuations are proportional to the temperature at the time of spawning, being particularly significant when spawning occurs above 4°C. If the spawning occurs after the lake has become isothermal at some value below 4°C, the eggs are assured of less drastic thermal changes. The explanation for these different levels of thermal damage centering around 4°C rests on two facts: the eggs lie on the bottom, and water has its maximum density at 4°C.

In contrast to the foregoing hypothesis, the delay in spawning accompanying late autumns may lead to a lower survival rate of the eggs. (Before entering into this, it must be clearly understood that the time of ovulation in the cisco relative to environmental temperatures is unknown). There may be a short limit to the length of time that the eggs remain viable subsequent to ovulation, though they be carried in the body cavity of the female. Witschi (1952, Cancer Research, 12: 763–786) has shown that this is true in frogs and Mršić (1923, Arch. Mikro. Anat. Entwicklungs mech. 98: 129–209) demonstrated it with *Salmo gairdneri*. However, Witschi added that the duration of the period of viability for the frog eggs increases considerably at lower temperatures. In the cisco held at temperatures below 4°C, the first signs of decreasing viability appeared 18 days after ovulation. No data relevant to this matter were obtained at temperatures above 4°C. The later spawning seasons concurrent with warm autumns appear superficially to be an inherent compromise designed to lessen the mortalities of eggs likely to occur either through a loss of viability before fertilization, or by temperature effects after fertilization.

This paper is taken from a thesis submitted in

partial fulfillment of the requirements for the degree of Doctor of Philosophy at the University of Wisconsin. The work was carried out in the Department of Zoology and was supported by grants from the Wisconsin Alumni Research Foundation and the Wisconsin Conservation Department. Thanks are due Dr. A. D. Hasler for his assistance throughout the course of this study; and to Mr. Ross Horrall, Dr. R. A. Ragotzkie and Dr. J. R. Nursall who, as fellow students at the Lake Laboratory, aided considerably in the fieldwork.—KENNETH R. JOHN, *Department of Biological Sciences, Northern Illinois State College, DeKalb, Illinois.*

PLASTIC BAGS FOR CARRYING AND SHIPPING LIVE FISH.—For several years tropical fish importers have been using plastic bags for shipping live fish by air, for packaging them for the retail trade, and for transporting them by motor vehicle. Since few ichthyologists appear to be aware of the use of such containers, it is the purpose of this note to call attention to the method and to its limitations and advantages.

An ideal shipping container should be durable but light, of sufficient capacity to hold a reasonable number of fish for many hours, readily portable, and economical. Plastic bags made of polyethylene appear to fulfill these requirements very well, and this plastic has the added advantage of allowing air to enter while retaining the moisture in the bag. Plastics are generally poor conductors of heat or cold and thus protect against temperature changes more effectively than do metal containers. When properly insulated, plastic bags maintain their temperature with remarkably little fluctuation over a period of many hours, even under subzero conditions.

A single-thickness bag 24 x 18 inches (capacity about 5 gallons) was used in making nine successful air shipments of live tropical fish (*Mollienesia, Poeciliopsis, Ilyodon*) from the mainland of Mexico to Tijuana, B. C. Shipping ports ranged from Guaymas, Sonora, southward to Manzanillo, Colima, along the western coastal plain and highlands from sea level to 5,200 feet. Except for one species (out of 12), mortality was negligible. Not more than about 2 gallons of water were used per bag (water depth 4 to 5 inches) and the number of fish shipped per container varied from 18 to 45 depending upon their size. After being filled with air, each bag was sealed about 5 inches below its neck by twisting the plastic and tying it securely, and then the neck was doubled over and tightly fastened with heavy rubber bands. This method lessens or prevents leakage if the container happens to be turned upside down in transit. The bag was then placed in a single-ply cardboard box insulated with a corrugated cardboard liner (a Jiffy bag liner is also satisfactory). The box was then securely sealed with Dennison's (1¼ inch) mending tape and tied to provide a handle. Not more than 48 hours elapsed from the time of air shipment until the fish were picked up at Tijuana by personnel at Scripps Institution of Oceanography; maximum time from capture to release in aquaria at La Jolla was 80 hours. Shipments were made between January 31 and April 3, 1955.

Reduced numbers (11 to 34 fish per bag) of the same species were sent in similar containers, but without insulation, by air express in mid-May from San Diego to Ann Arbor. Elapsed shipping time was 48 hours and all fish were in excellent condition on receipt.

Double-thickness bags are often used as added insurance against leakage, particularly for longer air shipments than those described above. Slight leakage did occur in some of the bags on the San Diego–Ann Arbor flight, evidently due to careless handling en route (boxes inverted). Such handling must be planned for, however. Pure oxygen may also be applied, first deflating the plastic bag and then forcing the oxygen in until it reaches the full size of the carton. The top of the bag is then twisted as described above, folded over, and sealed with a double heavy-gauge rubber band to prevent leakage of oxygen or water. In a double-thickness polyethylene bag with a square bottom 15 x 15 inches and a height of 23 inches, inflated with oxygen and filled with water to a depth of about 4 inches, 75 large mollies or 300 gambusias can be carried safely up to 36 hours (information from World-Wide Aquarium Supply Co., N. Y.).

The number of fish carried can be greatly increased by adding sodium amytal to the water and thereby slowing metabolism. Fishes so treated have been kept for a week without visible damage, and only about one-third of the ordinary shipping water is needed (the fish can be literally packed like sardines). However, the fish must have a complete change of water upon reaching their destination in order to bring them out of the enforced state of stupefaction. One-half to one grain per gallon of water has been used successfully in shipping tropical fishes (The Aquarium, 1954, 23(1): 17; 23(5): 142–43).

Further advantages of plastic bags over metal containers are that they prevent injury to fish bumping against the container walls, do not rust, and take up little room prior to their use in the field (a space 26 x 22 x 7 inches will accommodate 10 bags, insulated fillers, and cartons). Equalizaton of water temperatures between the plastic bag and the aquarium intended for the fish is readily accomplished by floating the bag in the aquarium. Their disadvantages are minor: (1) Life expectancy of the plastic is probably shorter than that of metal cans;

(2) the bags are more difficult to move about, particularly if one wishes to empty the contents into tanks that are above shoulder level; and (3) the fish cannot readily be removed with nets but must be poured into another container.

The following references to this method of live-fish shipment have been noted (in addition to the two cited above): The Aquarium, 1953, 22(7): 240–41, 2 figs.; 1954, 23(6): 184–85, 1 fig.; 1955, 24(4): 125–26, 2 figs. The Aquarium Jour., 1954, 25(12): 245–46. I am grateful to William T. Innes for calling my attention to some of these articles. The plastic bag technique has revolutionized the shipping and carrying of live fishes not only for the aquarium trade but for the experimental worker as well.

Funds to advance this study were provided by the Horace H. Rackham School of Graduate Studies of the University of Michigan.—ROBERT RUSH MILLER, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

Herpetological Notes

SOME OBSERVATIONS ON THE SALAMANDER, *STEREOCHILUS MARGINATUM*.—A natural nesting site and the hatchling larvae of *Stereochilus marginatum* were recently described for the first time by Schwartz and Etheridge (1954, Herpetologica, 10 (3): 167–71). I wish to make known some additional observations which corroborate their account in part.

On January 27, 1951, a nest of *Stereochilus* was found in one of the numerous ponds which dot the pineland near Cainhoy, Berkeley County, South Carolina, about 18 miles NNE of the tip of the Charleston peninsula. The particular pond supports gum trees (*Nyssa biflora*) only, but others in the area additionally or predominantly contain cypress (*Taxodium ascendens*). When the collection was made, the pond was about 40 feet in diameter with a broken border of wax myrtle (*Myrica cerifera*) and broom grass (*Aristida*) and with two dense beds of sphagnum moss in its shallow water (maximum depth about 2 feet). Inside a very mushy gum log, the bulk of which was situated above the water near one side of the pond, a large female *Stereochilus* was found curled about a mass of approximately 40 eggs. Near her there were about 20 other eggs, a total of 62 in all. There were no externally obvious openings in the log leading to the very small cavity containing the eggs. At the time, 12 noon, the temperature inside the log around the eggs was 7° C., that of the water 9° to 10°, and that of the sphagnum beds, 8°. There was still some ice in nearby ditches and ponds from the previous night's frost, and ground and water temperatures of 2° to 4° C. had been recorded from them earlier in the morning. Field notes mention that the female was very active.

The eggs were not far advanced in development. Diameter measurements of the outer capsules of six eggs in water showed more variation (2.5–3.4 mm.) than the five eggs measured by Noble and Richards (1932, Amer. Mus. Novitates, No. 513), but the average, 3.0 mm., is nearly the same as theirs (3.1 mm.). The number of egg agrees very well with their average of 57 for 19 clutches from induced depositions and stands in contrast to the low figure of 15 eggs found by Schwartz and Etheridge.

In the laboratory experiments of Noble and Richards, plant and stone laying sites in water were found to be preferred over available "land sites". Since a special search was being made for salamander eggs in the sphagnum beds in and about the ponds of the vicinity during the morning's collecting, it is doubly interesting that this natural site, like that found by Schwartz and Etheridge, was a microsituation out of water.

Larvae of *Stereochilus* collected by Thomas M. Uzzell, Jr., and myself nearby in Charleston County in May, 1951, are intermediate in development between the stage depicted by Bishop (1947, Handbook of Salamanders) and the hatchling larvae described by Schwartz and Etheridge (cf. Harrison and Quinby, 1955, Proc. Elisha Mitchell Soc., *in press*). The larvae and, as far as is precisely known from field collections, the egg sites and larval habitat are generally similar to those reported for *Manculus* by Goin (1951, Ann. Carnegie Mus., 32: 253–63). These similarities may indicate a closer relationship between *Manculus* and *Stereochilus* than has been deduced thus far on anatomical grounds. More likely, perhaps, they merely indicate convergent adaptation of the larvae to the same type of habitat and/or egg site. This would help to explain the otherwise puzzling similarity of both forms to *Hemidactylium*, which lays its eggs in sphagnum moss out of water in bog ponds and which is the only other plethodontid salamander having an aquatic larva with the dorsal fin extending onto the body.—GEORGE B. RABB, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

NOTES ON THE OCCURRENCE OF SOME OREGON SALAMANDERS CLOSE TO THE OCEAN.—On May 6, 1955, the Oregon Herpetological Society held its first annual meeting at Humbug Mountain State Park, Curry County, Oregon. The following is an account witnessed in part by several of the participating members.

Over a dozen individuals of *Taricha granulosa* Skilton were collected at 11:00 PM from Brush Creek directly under the new U. S. Highway No. 101 bridge at a point about 100 yards from where it empties into the Pacific Ocean. The salamanders, a pair of which was found in amplexus, were in shallow water along the edge of the stream. The stream is devoid of aquatic vegetation and streamside cover, the banks consisting of stream gravel, with some rip-rap under the bridge. The temperature of the water was 10° C.; that of the air, 7.5°.

About 11:38 PM a strong tide swept up Brush Creek, increasing the depth of the water by 13 inches at a point estimated to be 5 feet above sea level, continuing up the stream for a distance of nearly 300 yards. A search for *Taricha* after the tide subsided revealed several of them in the stream, emerging onto the rip-rap and stranded on the sandy beach near where Brush Creek runs into the ocean.

A male found on the beach was observed for some time. It seemed to be breathing quite rapidly (114/Min.) considering the temperature, which was 8.5° C. about one inch above the sand, and walked as though attempting to hold its body off the substrate. After a few minutes the animal moved down the beach to the creek, paused at the edge of the water, which was about 3 inches deep, and entered, remaining lodged against rocks on the bottom for 15 minutes. The creature appeared restless, climbing out on rocks for a few minutes, then re-entering the water. When an incoming wave inundated the stream channel, the animal jerked its head rapidly to one side, crawled out of the water and then back in again. A second wave washed the animal a few feet upstream and back to its original position at which time vigorous swimming movements were noted. For the next hour further observation revealed little activity except for rather nervous forays in several directions, a few inches at a time, including climbing out on rocks and hiding under them in the water.

A second male, collected on the beach, was placed in a small tide pool at the seaward end of a large rock. Incoming waves covered the pool with 1.5 to 2 feet of water. After each of four such waves, a search was made for the animal and it was discovered to have maintained approximately the same position despite the strong current accompanying the waves. After the fifth wave the animal could no longer be located. This experiment was repeated using three different individuals, and all but one were swept away by the first wave. The latter was retrieved and taken to camp, it appeared normal the following day.

At 7:45 PM on May 7, 1955 a female *Taricha* was found stranded on the beach during an incoming tide, about 45 yards north of the mouth of Brush Creek. Shortly after it was collected, the area where it had been was washed by a wave, and automobile tracks nearby, which had been made since the last high tide, were obliterated, indicating that the animal had probably been on the beach since the morning tide. The newt was extremely sluggish, coated with sand and its skin appeared in a wrinkled condition. It was rinsed in fresh water and taken to camp where, during the night, it showed little indication of being alive except exhibiting a righting reflex when turned over. By the next morning the salamander had fully recovered, and it was still alive at the time of this writing.

Nathan Cohen, Oliver Johnson and I collected three *Plethodon dunni* Bishop and a larval *Dicamptodon ensatus* Eschscholtz on May 1, 1955 near the mouth of a small creek which runs through Yachats State Park near Cape Perpetua, Lincoln County. The location was only 20–25 feet from a pile of driftwood and logs marking high tide level. The plethodons were under boards in a moist seep on the bank of the stream. Bracken fern, moss, horsetail, *Ribes* and *Tellima* were growing nearby, and an adjacent falls probably sprayed the area where the *P. dunni* occurred, minimizing the effect of salt spray if any.

I wish to thank the following people who have contributed their observations to my own: Dr. Robert Storm, Robert H. Storm, Oliver Johnson, Robert Murdy, Kay Payne, Al Mozejko, Merle Dade, and Nathan Cohen.—DENZEL E. FERGUSON, *Department of Zoology, Oregon State College, Corvallis, Oregon.*

RECORDS OF THE SPINELESS SOFTSHELLED TURTLE AND THE SNAPPING TURTLE FROM NEW MEXICO.—A female spineless softshell turtle, *Trionyx mutícus* Le Sueur, was found above Conchos Dam, altitude 4,250 feet, in San Miguel County, New Mexico on the Conchos River in the Canadian River drainage. The turtle weighed 2 pounds and 3 ounces. By straight-line measurement on the ventral side, the carapace was 8¼ inches in maximum length from margin to margin and 6¼ inches across between the fore and hind limbs. Captured in July, 1954, the turtle was kept alive in the campus greenhouse for several months. This specimen was found approximately 350 miles west of the margin of the previously described range, Tom Green County, Texas (Pope, 1946, Turtles of the United States and Canada) and at an altitude higher by around 2,000 feet.

On December 11, 1954, two men brought to the Department of Biology a male snapping turtle, *Chelydra serpentina serpentina* L., captured at Villanueva, altitude 6,700 feet, in San Miguel County, New Mexico, in the Pecos River drainage. The turtle weighed 10 pounds and 11 ounces. The carapace, by straight-line measurement from margin to margin on the ventral side, had a maximum length of 11 inches and was 9 inches wide between the fore and hind limbs. The distribution of this species was considered to extend westward only through the eastern two-thirds of Texas and north to the Oklahoma Panhandle and the Denver-Boulder region (Pope, *op. cit.*) until Koster (1946, COPEIA, (3): 173) reported it from New Mexico in the vicinities of Roswell, Santa Rosa and Wagonmound, in Chavez, Guadalupe and Mora counties, respectively. The specimen herein reported was found 66 miles west of any of Koster's collections and at an altitude higher by 500 feet.—LORA M. SHIELDS AND R. G. LINDEBORG, *New Mexico Highlands University, Las Vegas, New Mexico.*

SIZE AT SEXUAL MATURITY IN THE MALE SOFTSHELL TURTLE, *TRIONYX FEROX EMORYI.*—The sex of adult male turtles of the genus *Trionyx* usually can be ascertained on the basis of a thick, fleshy tail extending beyond the carapace. It is well known that adult males retain the juvenile markings on the carapace whereas the females lose these and acquire with increasing size a blotched or mottled pattern, which, in large individuals, may obscure the original pattern. The mottled pattern is apparent in females from Texas and Louisiana before sexual maturity is attained. This condition, therefore, is at variance with the supposition of Breckenridge (1955, COPEIA, (1): 6) who suggested that the definite mottled pattern in females indicates a stage in the attainment of sexual maturity. The size of females at sexual maturity is unknown but is greater than that of males; Cahn (1937, Illinois Biol. Monogr., 16 (1–2): 193) suggested that the females must attain a carapace length of about 24 cm. before they become sexually mature. In the largest male having juvenile markings, the plastron was 14.5 cm. long and the 55 turtles exceeding this length were females. It appears that the maximum plastron length of males is approximately 15.0 cm., and that most turtles exceeding this length are females with a mottled carapace.

Of male *Trionyx ferox emoryi*, a sample that includes a representative size distribution from one locality is lacking. The largest series available consists of 29 male turtles ranging in plastron length from 9.35 to 14.0 cm. An examination of this series (series A) from Marshall County, Oklahoma, collected from Lake Texoma at the University of

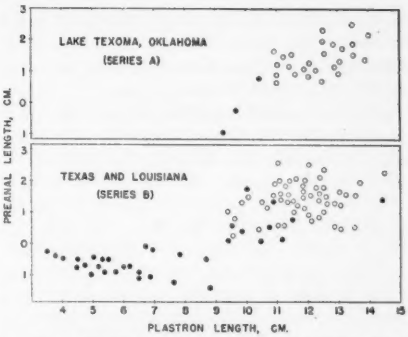


Fig. 1. The relation of preanal length to plastron length in *Trionyx f. emoryi*. Disks indicate sexually immature specimens; circles, sexually mature specimens.

Oklahoma Biological Station, indicates a plastron length of approximately 10.5 cm. as the size at sexual maturity. Of these, 16 specimens were preserved and have the following museum numbers: (Tulane Univ. 16076 (5), 16175 (6), 16662.1, 16662.2, 16662.4, and Univ. Oklahoma 27562–63).

My examination of turtles from other localities revealed that the male softshell turtles attained sexual maturity at the same plastron length as those from Lake Texoma did.

A selected series (series B), representing many sizes and including individuals from Texas and Louisiana, is compared with the Lake Texoma series (Fig. 1). Series B includes 93 specimens with extremes in plastron length of 3.54 and 14.5 cm.

Plastron length is measured midventrally from the posterior end of the plastron to the most anterior region of the ventral surface. This measurement, therefore, is not of the actual bony plastron, but includes the anterior cartilaginous part. This measurement is believed to be more accurate than the actual plastron length, as the anterior parts of the bony plastron are often indistinct and difficult to discern. Sex was determined by dissection and the males were regarded as sexually mature if sperm were present in the testes or vas deferens. As a criterion of the degree of sexual maturity, the specimens were measured from the rear edge of the carapace to the anterior lip of the cloaca; this is the preanal length. Preanal measurement is only possible if the anterior lip of the cloaca extends beyond the posterior border of the carapace. Postanal length is measured on immature specimens when the anterior lip of the cloaca does not extend beyond the posterior edge of the carapace.

The males in series B show an abrupt change in the relation of preanal length to plastron length (Fig. 1) when they attain a plastron length of 9–10 cm. In males, the extension of a thick, fleshy tail beyond the carapace is a secondary sexual character. The cloacal opening of the females examined

does not extend beyond the posterior edge of the carapace. This dimorphism has been mentioned previously by several authors but has not been correlated with size at sexual maturity.

In series A, three specimens, 9.36, 9.73 and 10.4 cm. in plastron length, are immature, whereas all other individuals, the plastrons of which exceed 10.0 cm., are sexually mature. All specimens in series B with a plastron length less than 9.0 cm. are immature; five of nine individuals in the 9.0–10.0 cm. size group, and eight of 11 specimens in the 10.1–11.0 size group are sexually mature. All specimens in series B exceeding 11.0 cm. in plastron length are sexually mature except three, the measurements of which are as follows: 11.2, 11.5 and 14.4 cm.

The occurrence of seemingly sexually immature individuals in the larger size groups of series B might be due to individual or geographic variation. On the other hand, due to senility or to the season of the year, sperm might be absent; or the technique used by me is not definitive for ascertaining sexual maturity in such instances. However, from the testes of the six sexually immature specimens exceeding 10.0 cm. in plastron length, smears were made several times, but sperm was not detected. The individual 14.4 cm. in plastron length was obtained in February, and the other five individuals in April and June.

Males of *Trionyx f. emoryi*, and possibly males of the other subspecies as well, thus usually become mature when they reach a plastron length of 9–10 cm. Elongation of the tail beyond the carapace is correlated with the attainment of sexual maturity. The juvenile color pattern of the carapace is retained in adult males. Females attain maturity at a larger size than males and the mottled pattern of the carapace of females, which is acquired with increasing size, is not correlated with size at sexual maturity.—ROBERT G. WEBB, *Department of Zoology, University of Kansas, Lawrence, Kansas.*

AN UNUSUAL AGGREGATION OF *PLETHODON GLUTINOSUS* AND REMARKS ON ITS SUBSPECIFIC STATUS.—On September 12, 1951, the writer, accompanied by Dr. D. C. Scott and Mr. Allan Hirsh, found an unusual aggregation of *Plethodon glutinosus* in Utley's Cave, Burke County, Georgia. The locality is a small limestone cave with a small stream issuing from it. It is located approximately 15 miles ENE of Waynesboro, Georgia, and one mile W of the Savannah River.

Thirty-seven individuals of *P. glutinosus* were found throughout the 50 feet of the cave we could enter. They were found clinging to the walls of the cave, in crevices in the limestone and clay, and under slabs of the same substances. The mouth of the cave opened into a ravine which was covered with a climax Oak-Hickory forest, usually good habitat for *P. glutinosus*. Yet, on this occasion no specimens were found in the ravine.

The salamanders were found during a prolonged drought and the litter and soil of the forest floor were extremely dry. Weather Bureau records for the nearest station, Waynesboro, indicate that during the preceding summer months rainfall was much below normal and temperatures were exceptionally high. In fact, for the month preceding, there was no rainfall, a deficit of 5.4 inches. Daily maximum temperatures were all above 90° F. with a mean temperature of 83°.

Thus it seems that this aggregation of *P. glutinosus* resulted from a movement of salamanders from the dry ravine into the more moist and humid conditions of the cave, presumably to escape the unusually dry conditions of the usual habitat. Some salamanders probably also remained in the ravine but went deeper into the substrate to escape the dry conditions. On several other occasions both before and after this date, when more normal conditions prevailed, no plethodons have been seen in the cave at all, but they have been taken in the ravine.

A similar effect was observed in Bartow County, Georgia, on October 30, 1952, when two specimens of *P. glutinosus* were taken from crevices in Saltpetre Cave but none were found in good but dry habitat outside. Similar weather conditions prevailed and the locality was very much like that at Utley's Cave.

Shelford (1913, Biol. Bull., 25 (2): 79–120) found some indications that *P. glutinosus* can orient to moisture gradients in air. This suggests how these specimens found their way into the cave, if a current of more moist air were flowing from it as might be expected. The only reference to *Plethodon* inhabiting caves that has been found is that of *P. dixi* (Pope and Fowler, 1949 Nat. Hist. Misc., 47: 1–4), but caves are apparently the usual habitat of this species.

The binominal, *P. glutinosus*, has been used in reference to the Utley's Cave specimens because this series does not conform with any of the presently described subspecies of *P. glutinosus*. Since this locality is on the edge of the published range of *P. glutinosus grobmani* (Allen and Neill, 1949, Herpetologica, 5 (6): 112–4), a comparison between the Utley's Cave specimens and *P. g. grobmani* is in order. Allen and Neill (*op. cit.*) are relied upon for a description *P. g. grobmani*.

P. g. grobmani is characterized by tiny golden dots on the dorsum, large lichenous, dull white or gray lateral spots, 14 or 15 costal grooves, and an average adult snout-vent length of 53.7 mm. The 37 specimens from Utley's Cave have the following characters: the dorsum is black with very few tiny irregular flecks of gray except for five individuals

in which the flecks are yellowish; the sides of the body are marked with a few small white flecks over large indistinct gray spots, but this spotting is not very extensive in any specimen; there are 15 costal grooves, counting one in the axilla and two in the groin, in all except one specimen with 16 and one with 14; the average snout–vent length is 51.6 mm., with extremes of 44.6 and 64.8.

It is beyond the scope of this paper to attempt a critical analysis of the validity of *P. g. grobmani* but a few remarks are in order. Apparently the only diagnostic character of *P. g. grobmani* is the presence of golden dots on the dorsum. The smaller size is to be found in local populations of *P. glutinosus* from other parts of its range. As for the other characters, there is a certain vagueness which leaves much to be desired. The lateral color differences are slight and hard to determine. The method of counting costal grooves was not given in the original description. Bifurcate costal grooves are of common occurrence in the axilla and groin of *P. glutinosus*, and whether these are counted as one or two makes a great deal of difference. In the counts given for the specimens concerned with in this paper the maximum number were counted, bifurcate grooves counted as two. Only a few of the Utley's Cave specimens had the apparently diagnostic golden dots.

Direct comparisons were made between the Utley's Cave specimens and a series of 16 *P. glutinosus* from southern Screven County, Georgia. These Screven County specimens supposedly should be *P. g. grobmani*, since they were collected within 5 miles of the locality of one of the series of paratypes (Allen and Neill, *op. cit.*). These 16 specimens show the following characters: few to many dorsal spots of gray; sides with many large, indistinct, regular, grayish spots; costal groove counts are 16 in five, 15 in eight, 14 in three; the average snout–vent length is 55.9 mm., with extremes of 47.4 and 61.9. Thus these specimens do not fit the published description of *P. g. grobmani* but rather differ more than do those from Utley's Cave.

Allen and Neill (*op. cit.*) listed the range of *P. g. grobmani* as extending from northern Emanuel and Screven counties, Georgia, eastward to the Savannah River in Georgia, southward to Pinellas and Hillsborough counties, Florida, and westward to the Dougherty Plain, Georgia. However, all the specimens of *P. g. grobmani* actually examined by Allen and Neill (*op. cit.*) were either from the type locality, Marion County, Florida, or Emanuel, Effingham, or Screven counties, Georgia. These latter specimens from Georgia are listed as paratypes, a doubtfully sound procedure since they are from the extreme of the listed range. In fact the Georgia paratypes are separated from the type locality by a distance of over 200 miles and no specimens from the intervening area were actually examined.

In view of the differences enumerated above and the discontinuous range of *P. g. grobmani*, the specimens concerned with in this paper and other specimens from the Coastal Plain of Georgia should be referred to *Plethodon glutinosus*, at least until more studies are made of the variations within these populations. A good example of such a study is Neill's paper on a variant population of *P. glutinosus* in South Carolina (1948, COPEIA, (4): 247–51).

Bogert (1954, Syst. Zool., 3 (3): 111–2) has aptly stated presently accepted ideas on the practice of applying subspecific names to local infraspecific variations without careful analysis.—ROBERT L. HUMPHRIES, *Department of Zoology, University of Georgia, Athens, Georgia.*

ANOTHER DEVICE FOR COLLECTING LIZARDS.—Many herpetologists, in areas where firearms could not be used, have killed or stunned lizards by means of a stout rubber band, discharged from the hand or from a wooden "gun." A number of these simple collecting devices have been discussed in the literature, and I would hesitate to comment further on the subject were it not that the one described herein has several advantages over other models.

This gun is simply a small board with a series of notches cut in it. The board may be whittled into the shape of a rifle, if desired, but this is not necessary. A rubber band is stretched from the "muzzle" to a notch, as shown in the accompanying sketch (Fig. 1). A number of bands can be loaded, one to a notch. Since the bands overlap each other at the muzzle, the last one loaded must be the first one discharged; usually this should be the one with the least tension. Then, if the first "shot" misses, successive and more powerful shots may be fired as the quarry makes off.

The release of a rubber band is accomplished by rolling it upward over its notch, using the thumb of either hand (see figure). It is best, when starting on a collecting trip, to roll each band upward until it nearly disengages its notch; then a single slight fillip will suffice for release. Of course, strong and

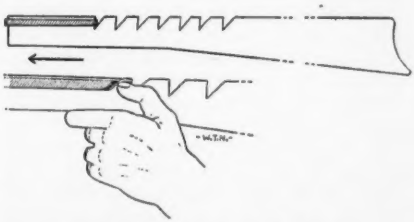


Fig. 1. Simple device for collecting lizards.

highly elastic rubber bands should be used for best results. Synthetic rubber is often unsatisfactory, as are strips cut from automobile tire inner tubes.—WILFRED T. NEILL, *Research Division, Ross Allen Reptile Institute, Silver Springs, Florida.*

SOME COLOR ABNORMALITIES IN CROCODILIANS.—Color abnormalities, such as melanism, erythrism, and partial or complete albinism, have been observed in a number of reptiles, especially various snakes and turtles. These abnormalities have not often been noted among the Crocodilia, and so it may be of interest to report on a few unusually colored specimens of that order.

In April, 1954, we received a melanistic spectacled caiman (*Caiman sclerops*). It was shipped with some normally colored individuals from Barranquilla, Colombia, and probably had been collected in that vicinity. It was completely black above and below, except for an irregular grayish area along the midline of the belly. Even the iris of the eye was black. The specimen was a juvenile, about 10 inches in total length. Normally colored juveniles from the Barranquilla region are yellowish white below and greenish brown above, with blackish crossbands on the dorsum of body and tail; the iris is very light greenish-gray.

Over a period of years we have examined many thousands of American alligators (*Alligator mississipiensis*), but have never seen a melanistic specimen. However, captive alligators, kept in unshaded pens, soon become nearly or quite black on all the upper surfaces. These supposedly "sun-tanned" examples differ strikingly from wild ones of the same provenience. Old alligators, wild or otherwise, normally become very dark above, but are not melanistic in the usual sense of the word.

The St. Augustine Alligator and Ostrich Farm received an erythristic alligator and a somewhat albinistic one. In the former, all the normally blackish areas of the body were reddish brown. The latter specimen was light grayish yellow with slightly darker markings on the tail and sides of the body. Both of these alligators were adults. In captivity they darkened noticeably over a period of years; evidently they were physiologically capable of producing some melanin.

The senior author and his brother, Oliver P. Allen, caught a light-colored alligator between Winter Haven and Lake Alfred, Polk County, Florida, in 1925. It was 23 inches in total length. The bright yellowish crossbars, characteristic of juvenile alligators, were present; but the ground color, normally dark, was a pale yellowish, lighter than the crossbars. The specimen is still alive, now measuring about 8 feet in length. It has gradually darkened in captivity, and today is not conspicuously lighter than others of its kind. Most of this darkening took place in the last 3 or 4 years, when the reptile was kept in a pen with but little shade.

In September, 1938, a number of baby alligators, each about 8½ inches long, were discovered at a single locality on the St. Johns River in Lake County, Florida. They evidently represented one brood which was just beginning to disperse. One of the lot was albinistic, perhaps a little lighter than the Polk County specimen mentioned above. Its eyes were dark reddish in color. The others of the "brood" were normally pigmented.

McIlhenny (1935, The alligator's life history: 18–9) mentioned a light yellow alligator, 7½ feet in length, and a smaller example with a yellow tail. Other literature records of abnormally colored alligators have not come to our attention.—E. ROSS ALLEN and WILFRED T. NEILL, *Ross Allen Reptile Institute, Silver Springs, Florida.*

SNAKES FOUND DEAD ON THE ROADS OF NEW MEXICO.—The writer finds it necessary to do considerable driving within the borders of New Mexico during every month of the year. Advantage has been taken of the opportunity thus afforded to collect such snakes found dead on roads (DOR) as appeared to be worth saving. These specimens have customarily been donated to the University of New Mexico. In addition to this random collecting, exact records of miles traveled in relation to numbers of snakes seen DOR were kept during the calendar years 1951, '52 and '53. Only travel during daylight and under otherwise favorable observing conditions was counted. The records were arbitrarily limited to travel on federal and state highways, both types including paved and unpaved roads. The area covered provided, nearly every month, a sample of most of the main habitat types of New Mexico south of an east-west line at the approximate latitude of Santa Fe. The travel was ordinarily at speeds of around 50 m.p.h. Since time could not be spared to stop and identify each DOR seen, they were simply lumped together in the record as "snakes."

The first two years of these observations have already been reported by the writer (Herpetologica, 9 (3): 157–60). The observations were discontinued as of the end of 1953, since making them proved to interfere with other observations more vital in the writer's work. This being the case, it is felt that the 1953 data, as well as certain incidental 1954 observations, should perhaps be put on the record at this time.

These data for 1953 are as follows: Jan., 1,686 miles, 1 snake DOR, 0.0006 snake per mile; Feb., 1,388, 0, 0.0; Mar., 1,755, 0, 0.0; Apr., 1,261, 5, 0.0040; May, 871, 34, 0.0390; June, 1,391, 38, 0.0273; July, 711, 14, 0.0197; Aug., 865, 18, 0.0208; Sep., 1,236, 16, 0.0129; Oct., 1,022, 12, 0.0117; Nov.,

843, 6, 0.0071; Dec., 1,063, 0, 0.0; annual totals, 14,092, 144, 0.0102.

The previous annual totals were as follows: year 1951, 14,268 miles, 72 snakes DOR, 0.0050 snake per mile; 1952, 14,145, 89, 0.0063.

The general seasonal pattern in 1953 was similar to that of 1951 and 1952, although the monthly maxima fell in different months in each case. Further, in 1951 and 1952 no DORs were observed in January, February, March or December. The one snake seen DOR in January, 1953, was a small *Crotalus viridis*, seen on the 4th just south of Albuquerque during a spell of unseasonably warm weather.

Nearly all the annual road kill of snakes in New Mexico apparently occurs during the eight-month period of April to November, inclusive. During the four-year period 1951–54, in the course of over 100,000 miles of driving in country which could be expected to produce snakes, the writer saw only three exceptions to the rule that no snakes will be found DOR in New Mexico during January, February, March or December. These three exceptions were all seen during periods of unseasonably warm weather. One was the rattlesnake mentioned above. The others were a small *Piluophis catenifer* and an unusually large *Masticophis flagellum*, seen DOR in southeastern New Mexico on December 19 and 20, respectively, 1954.

In the previous paper, an attempt was made to estimate the total numbers of snakes killed by automobile traffic in New Mexico during 1951 and 1952. The method used in arriving at these rough estimates was as follows: (1) basic rate per mile on federal and state highways equals number of snakes DOR divided by number of miles of observation; (2) rate per mile per month equals results of (1) multiplied by 10.0 or 10.3, for 30- and 31-day months respectively; this assumes that, on the average, DORs will remain present and recognizable from a moving car as snakes for 3 days; (3) total number of snakes DOR on federal and state highways each month equals results of (2) multiplied by 10,770 (miles), plus 10 percent to correct for DORs present but not seen; (4) final monthly totals secured by adjusting the totals of (3) in the light of the following considerations: 52,741 miles of other established public roads in New Mexico; average kill per mile on these roads assumed to be 10 percent of that on the main highways; (5) annual total equals sum of monthly totals.

On this basis, the calculated 1953 total of snakes DOR in New Mexico would be 25,744. The 1951 and 1952 totals were similarly calculated at 10,489 and 13,840, respectively. The reasons for the progressive increase are not known. These estimates are all considered to be conservative, but no serious drain on the snake fauna of the state from highway mortality during the period covered seems indicated.

As to kinds of snakes DOR, in the previous paper the writer stated his impression that the following species are most often seen, probably in the order named: *Piluophis catenifer*, *Crotalus* (mainly *viridis* and *atrox*), *Masticophis flagellum*, and *Heterodon nasicus*. Subsequent observations have not changed this impression, except to raise some doubt as to whether *Crotalus* or *Masticophis* should be accorded second place.—Howard Campbell, *Department of Game and Fish, Albuquerque, New Mexico.*

NOTES ON THE SNAKE, *SISTRURUS CATENATUS TERGEMINUS*, IN SOUTHWESTERN KANSAS AND NORTHWESTERN OKLAHOMA.—During the past three years, three specimens of *Sistrurus catenatus tergeminus* Say have been taken in the general area of southwestern Kansas and northwestern Oklahoma, a region from which the subspecies has not been reported, by members of the University of Michigan Paleontological Field Party. The specimens are in the collections of the Museum of Zoology, University of Michigan (UMMZ).

On June 26, 1952, a male specimen, UMMZ 107958, was taken by Clarence L. Smith, Jr., from the Michigan-Wisconsin Pipe Line Pumping Station on the XI Ranch, SE¼ Sec. 21, T34S, R29W, Meade County, Kansas. It has 23–24–19 dorsal scale rows, 147 ventrals and 30 caudals. Its total length is 250 mm., its tail length 25 mm., and it has one rattle and a button. Its ground color is a darker brown than that of the specimens mentioned below.

On July 4, 1954, a male, UMMZ 111589, was taken by Claude W. Hibbard and Thomas M. Oelrich on the east side of Buckshot Arroyo in the NE¼ SW¼ Sec. 5, T5N, R26E.C.M., Beaver County, Oklahoma. It has 21–23–17 dorsal scale rows, 140 ventrals and 29 caudals. Its total length is 350 mm., its tail length 33 mm., and it has four rattles. Its ground color is light greyish brown and its ventral surface had a light pink hue when first caught.

The third specimen, a female, UMMZ 110868, was taken on August 26, 1954, by Claude W. Hibbard on the XI Ranch, NW¼ Sec. 25, T34S, R30W, Meade County, Kansas. It has 25–25–19 dorsal scale rows, 149 ventrals and 30 caudals. Its total length is 570 mm., its tail length 60 mm., and it has eight rattles. Its ground color is light grayish brown and, like the other two, its pattern is very distinct, its blotches being outlined in dark brown and thinly bordered with white. Its ventral surface is much lighter than its ground color and is sparsely marked as are the ventral surfaces of the other two specimens.

I found that all three specimens have the follow-

ing characteristics in common: the rostral scale is higher than wide, the canthus rostralis is distinct, and only the first two rows of the dorsal scales are not keeled. The upper preocular is in contact with the postnasal, and the lower preocular forms the upper posterior border of the pit and is separated from the postnasal by a loreal. The lacrimal separates the fourth and fifth supralabials from the orbit.

It may be well to emphasize the fact that all three of the snakes were found in sage-brush habitats and that the residents of the area refer to them as "sagebrush rattlers."

I am indebted to Dr. Claude W. Hibbard of the University of Michigan Museum of Paleontology and Dr. Norman E. Hartweg of the University of Michigan Museum of Zoology for help given in preparing this note.—MICHAEL O. WOODBURNE, *2023 Devonshire Rd., Ann Arbor, Michigan.*

NEMBUTAL AS A KILLING AGENT FOR AMPHIBIANS AND REPTILES.—Veterinary Nembutal (Pentobarbital Sodium), as sold by Abbott Laboratories, Chicago, is not in wide-spread use by herpetologists and others as a killing agent for amphibians and reptiles. As this may be partly due to unfamiliarity with the method, this note has been prompted. The use of nembutal excells other traditional methods currently employed for killing these and other animals for it is handled simply, requires a minimum of space and equipment, kills in seconds if desired, and leaves the animal's body immediately relaxed and without damage to external or internal structures.

The first use of nembutal for this purpose that I am aware of was by Dr. Malcolm R. Miller and the author in 1940 at the University of California, Los Angeles, for the purpose of rapidly killing a female rattlesnake for examination of corpora lutea. The results were so gratifying that nembutal became immediately favored for the killing of reptiles and amphibians both in the field and laboratory.

The preferred cite of injection, size and health of the animal, and the desired time lapse prior to death, are factors normally determining the particular overdosage (to kill) used. Dosages of 1.0 to 5.0 cc. ordinarily kill, in 5 to 10 minutes or less, all of the smaller snakes under 4 feet in total length, when injection is made into the body cavity in the region of the heart. Amounts less than 1.0 cc. may be used satisfactorily for very small lizards, snakes, turtles, frogs, etc. Larger amounts administered in the region of the heart give more rapid results, killing in but a few seconds. Satisfactory injection may be made, with or without a needle on the syringe, through the vent and into the hindgut when such is preferred or is necessary.

These remarks primarily apply to the problem of killing amphibians and reptiles for general museum, laboratory, and field purposes of gross examination and/or preservation.

While this note was in press, a study was reported in which Nembutal, Pentothal Sodium, and M.S. 222 were experimentally tested for anesthetization dosage for snakes (Karlstrom and Cook, 1955, *Copeia*, (1): 57–58).—CHARLES H. LOWE, JR., *Department of Zoology, University of Arizona, Tucson, Arizona.*

THE MOTTLED ROCK RATTLESNAKE, *CROTALUS LEPIDUS LEPIDUS*, IN EDWARDS COUNTY, TEXAS.—The type locality for the mottled rock rattlesnake is Presidio del Norte and Eagle Pass, Texas. The present locality records by counties in Texas are Brewster, Culberson, Jeff Davis, Presidio, Real, Terrell, Val Verde (Klauber, 1952, Zool. Soc. San Diego Bull., (26): 50) and Pecos (Brown, 1950, Baylor Univ. Studies: 220). Locality records for this species in Texas are scattered, and a gap has existed between Real and Val Verde counties in the southwestern part of the state. A recent collection of a single specimen of *Crotalus lepidus lepidus* in Edwards County closes the aforementioned gap. The purpose of this note is to further define the range and morphologica characters of this species in this part of its range.

On April 17, 1954, I received a specimen of *Crotalus lepidus lepidus* from Harvey Adams, Game Warden of the Rock Springs, Edwards County district. This individual was captured 10 miles south of Rock Springs, elevation 2,000 feet, Edwards County, on a rocky hillside. The characteristics of this individual are as follows: sex, male; scale rows, 26 (23) 19; ventrals, 164; caudals, 25; preoculars, 4–4; postoculars, 5–5; infralabials, 12–12; supralabials, 13–12; total length, 594 mm.; tail length, 50 mm.; the number of scales in the internasal-prefrontal area are nine; the minimum number of scales between the supraoculars, three; the number of rattle-fringe scales are 12.

This specimen differs from Klauber's (*loc. cit*: 50) account of the head scales of the southeastern forms as follows: the scales of the head only slightly rugose; the postnasal separated from the first supralabial; the suboculars and supralabials not in contact, and two canthals, both rather large and flattened.

The body pattern consists of 21 distinct primary crossbands. The crossbands are brown on a bluish grey background with three intermediate or secondary blotches between each pair of primary crossbands. These intermediates are indistinct and have sparsely scattered black-tipped scales. The post-

ocular dark stripe is present but indistinct and the occipital blotches are paired but not clearly outlined. The belly is heavily mottled with black. The tail bands are three, quite distinct, brown to black, and greatly contrasting with the tan ground color of the tail.—JAMES R. DIXON, *Department of Wildlife Management, Agricultural and Mechanical College of Texas, College Station, Texas.*

REVIEWS AND COMMENTS

THE REPTILE WORLD. By Clifford H. Pope. Alfred A. Knopf, New York: xxv + 325 + xiii, 221 pls., frontispiece in color. $7.50.—Clifford Pope's books, *Snakes Alive and How They Live* and *Turtles of the United States and Canada* are among the finest examples of popular writing in herpetology. They combine scientific accuracy with delightful style and readability. Probably more than any other book *Snakes Alive* influenced my own interest in reptiles and it is the book I recommend when a request comes for information about snakes.

Pope now presents us with another outstanding publication, one that fills a need long felt by those who teach herpetology. Until now there has been no comprehensive, up-to-date survey of the reptiles of the world in a single, reasonably priced volume. The book sets forth in order the living reptiles—crocodilians, the tuatara, turtles, and snakes and lizards, giving in a general introductory account for each, information on size, age and growth, distribution, food habits, reproduction, and so on. The topics considered vary with the group; thus in the account of snakes, in addition to the topics listed, are sections on origin and structure, hibernation, enemies and defense, care of pets, habitat, locomotion, popular beliefs, and prevention and treatment of snakebite. The account of turtles includes information on sunning, senses and intelligence, and relations to man; the section on crocodilians describes methods of hunting them for scientific purposes and relates the experience of an authority on crocodiles, Dr. Frederick Medem of the Universidad Nacional, Bogotá.

There are accounts of the families of each major group in which introductory remarks set forth the distribution and relationships of each family and its number of genera and species. Points of special interest such as probable evolutionary history and the amount and kind of adaptive radiation shown by the family are discussed. For purposes of discussion, grouping of the families of the larger taxonomic units has often been dictated by convenience and may be taxonomic or geographic. The author has been considerate in giving alternate technical names for a number of groups and species, especially in those instances where there has been instability or a recent change in nomenclature.

Many interesting species are treated under the family headings and by virtue of Pope's lively writing and the many excellent photographs, names that before may have had a dull ring now spring to life. For example, in my lectures in herpetology I have long referred to the caiman lizard, *Dracaena guianensis* (which I have never seen) calling attention to its mollusk-feeding habits and unusual dentition. The treatment of this lizard in Pope's book is the next best thing to seeing it alive. Isabelle Conant's clear photograph of the animal with a snail poised in its jaws, along with the well written text give the student at a glance a much more lasting impression than the most detailed spoken-word picture.

The illustrations, with but few exceptions, are superb and have been contributed by some 20 institutions or individuals, including the author. By far the greatest contribution was made by Isabelle Hunt Conant (57 photographs). Every one of these is outstanding in its clarity and effectiveness of pose. Other important contributors have been Charles Bogert and the American Museum of Natural History, the New York Zoological Society, and the Zoological Society of Philadelphia. The excellent, and previously published pictures, of the combat "dances" of male red diamond rattlesnakes and pine snakes by G. E. Kirkpatrick (courtesy of the Zoological Society of San Diego) are included as are also high speed photographs of the strike of a prairie rattlesnake, by Walker Van Riper of the Denver Museum of Natural History.

It is refreshing to see so many new pictures. It appears that a large portion of them have never been published before and their contribution to the book is tremendous. The 233 photographs are arranged together (except for the frontispiece) within or at the end of the account of each major reptilian group, 1 to 3 per page. Emphasis is on identification and but few show habitat or other types of background. An attractive colored picture of the Arizona

coral king snake serves both as the jacket design and colored frontispiece.

A useful bibliography (200 references) follows the account of each group and cites the works of authors referred to in text (usually by name only) and includes other references of special usefulness in gaining a general knowledge of herpetology on a world basis.

I can find little to complain about in Pope's book. On page 76 perhaps man's capacity for exterminating other animal life may be underestimated. Certainly much progress has been made toward reducing populations of the green turtle in the Gulf of Mexico. It is unfortunate that the recent information on *Lanthanotus* brought out by Mcdowell and Bogert (1954, Bull. Amer. Mus. Nat. Hist., 105: 1–142) was not available in time to prevent continuation of the inappropriate wedlock of *Lanthanotus* and *Heloderma* (page 313) but every writer is plagued with this type of thing. On page 282 it appears that the habits of *Uta mearnsi* are confused with those of *U. graciosa*. A hooked crowbar (page 291) is what many western herpetologists use in overturning Joshua tree debris to capture *Xantusia vigilis*.

The over-all excellence of this herpetological landmark in both quality of text and illustration will not be matched for a long time to come.—ROBERT C. STEBBINS, *Museum of Vertebrate Zoology, University of California, Berkeley, California.*

SYSTEMATIK DER REZENTEN KROKODILE. By Heinz Wermuth. Mitteilungen aus dem Zoologischen Museum im Berlin, 1953, Band 29, Heft 2, pp. 375–514, 66 text-figs.—This exceedingly useful review of the classification of living crocodilians is the work of the curator of herpetology at the Berlin Museum. As stated in the introduction, Dr. Wermuth has attempted to bring up to date the section on the Crocodylia presented by Boulenger over 60 years ago in his classic (1889) *Catalogue of the Chelonians, Rhyncocephalians and Crocodiles in the British Museum (Natural History)*. The project has entailed an extensive critical study of the literature with particular reference to the important post-Boulengerian papers of Kälin, Mertens, Mook, L. Müller, K. P. Schmidt, Werner and Wettstein. Wermuth has also personally examined 290 preserved specimens and 360 skulls, mostly located in German collections, in preparing this report.

The paper is divided into two principal parts. The first (51 pp.) is an excellent though brief account of the pertinent external and internal characteristics utilized in classification of the group, a consideration of the distribution and general ecology of the alligators, crocodiles and gavials and a detailed discussion of previous classificatory systems and nomenclatural problems. The section on systematic characteristics is well illustrated by a series of lucid diagrams.

The remainder of the paper (76 pp.) is concerned with definition, description and illustration of the systematic units recognized in the order Crocodylia. Three families, eight genera and 21 species are considered. Several forms usually treated as species by American authors are reduced to subspecific status on the basis of allopatry: *Caiman fuscus* (Cope) and *Caiman yacare* (Daudin) are placed under *Caiman crocodilus* (Linné); *Osteolaemus osborni* (Schmidt) is regarded as a subspecies of *Osteolaemus tetraspis* Cope; and *Crocodylus mindorensis* Schmidt is placed with *Crocodylus novaeguineae* Schmidt. The nomenclature for South American forms differs from that employed in this country, *Caiman crocodilus* (Linné) being used instead of *Caiman sclerops* (Schneider) for the spectacled caiman.

Excellent keys to the families, genera, species and subspecies of all living crocodilians are given. Detailed definitions of each genus and summary descriptions of each species and subspecies are presented. Particular emphasis is placed upon the characteristics of the head and skull in definitions and descriptions. This emphasis is reflected in the illustrations and the head and skull of all known species are adequately figured and the differences in these regions between subspecies are also shown. The synonymies under each group are in abbreviated style. The bibliography is restricted to references cited in the text and does not include articles listed in the synonymies. There is an excellent index to the entire work.

In a systematic review of this type several omissions are particularly irritating. First, although Wermuth gives a complete discussion of the morphologic features (especially dentition, hyoid apparatus and atlas) that serve to separate the Alligatoridae from the Crocodylidae, he makes no mention of these structures in the Gavialidae. Second, there is no indication as to the number of specimens of each species actually examined, and the impression is created that a great deal of the descriptive material is drawn from the literature. Third, the statement of range for each form is far too brief and should have included a more extensive listing of locality data, either from the literature or of specimens at hand. A valuable improvement would have been the inclusion of distribution maps. Four, the generic synonymies present no information on how the generic types were determined. Are the listed type species monotypes, tautotypes, types by original designation or by subsequent designation? In addition, no type is given for any generic name placed in synonymy by Wermuth. Five, type localities ought to have been given for all specific and subspecific names reduced to synonymy. Finally, there is abso-

lutely no information on the relationships or evolutionary patterns in living crocodilians, a most serious defect in any work purporting to be of a systematic nature.

In spite of these criticisms, Wermuth's report is undoubtedly an indispensable identification manual, a guide to the basic literature on the crocodiles and the foundation for future work on the group. That there is still need for additional studies on the living members of the order is exemplified by the recent discoveries of Dr. Fred Medem on South American caimans, the paucity of life history and ecologic data on the group and the absence of any clear understanding of the interrelationships of the living forms, either to one another or to fossil species. Until such data can be brought together with previously accumulated information into a complete revisional study of the crocodiles, Wermuth's critical review will form the most important single work on the order.—JAY M. SAVAGE, *Department of Zoology, Pomona College, Claremont, California.*

WILD AMERICA. By Roger Tory Peterson and James Fisher. Houghton Mifflin Company, $5.00: 434 pp., 128 illus.—"If you come to America . . . I will meet you in Newfoundland and conduct you around the continent." This is a fitting quotation with which to introduce this review of a book which is an account of a fabulous 100 day, 30,000 mile trip made by Roger Tory Peterson and his English colleague, James Fisher, as they travelled around the perimeter of the continent, covering more of the North American wilderness than even John James Audubon in his travels. Each of the 36 chapters is introduced by Peterson who then turns the narrative over to Fisher who writes directly from his daily diary. The titles of these chapters themselves, such as Atlantic Gateway, City in the Woods, Kites over the Sawgrass, Lydia Ann, South of the Border, Desert Gardens, Pleistocene Giants, Deep Blue Lake Cave Dwellers of Destruction, and the Islands of the Seals, convey some idea of the many places visited and described in this most readable and interesting book. These places included the Great Smokies, Everglades, Dry Tortugas, Avery Island, Xilitla (Mexico), Big Bend, Canyon de Chelly, Grand Canyon, Coronado Islands, Salton Sea, Yosemite, Crater Lake, and the Pribilofs. Throughout the book are scattered 128 superb pen and ink illustrations by Roger Peterson which highlight the great variety of wildlife and wild places seen on this incomparable journey. Herpetologists will be pleased to find illustrations of the spring peeper, chameleon (*Anolis*), coral snake, alligator, collared lizard and Gila monster. Incidentally, references to herpetofauna are few and only incidental in a text which is more concerned with avifauna as might be expected since the authors are ornithologists. This is not to say that birds are emphasized to the exclusion of other observations and comments (the rather complete discussion of the life-zone concept of Merriam in connection with the chapter on the Chiricahuas, for example). Moreover, a great deal of information can be gleaned from this book concerning some of the outstanding wilderness areas of our country, areas such as are found in our National Parks and Monuments, National Wildlife Refuges and Audubon Sanctuaries. But even more significant are the impressions of an Englishman seeing these sights, so many of which we take for granted, for the first time. He says, "I hope you Americans will always hold on to these primitive areas. We would give our souls to have some of them on our side of the Atlantic. You cannot realize until you are as crowded as we are how important wilderness values are." To this he later adds a final statement of praise for the manner with which we have preserved and protected these areas by saying, "... never have I met such wonders or met landlords so worthy of their land. They have had, and still have, the power to ravage it; and instead have made it a garden." Let us hope that we may continue to deserve such praise for the guardianship of our wilderness heritage, and continue to resist all efforts to exploit or otherwise despoil these areas.—JAMES A. FOWLER, *Academy of Natural Sciences, Philadelphia, Pennsylvania.*

THE TROPICAL RAIN FOREST. By P. W. Richards. Cambridge University Press, New York, 1952: xviii + 450, 15 pls., 43 text figs. $12.50.—In this valuable book Professor Richards offers a monographic treatment of the broadleafed evergreen forest—the most complex and the most productive of the world's plant formations, and the one most consistently misrepresented in the reports of excited travelers. He incorporates a wealth of personal experience and an exhaustive collation of published data into a careful synthesis which not only constitutes a mine of information but affords hitherto unavailable insight into the state of tropical plant ecology today.

The book comprises an important introduction, six parts and a postscript. The herpetologist will probably find in the introduction some of the most stimulating material in the book, since it is here that the writer discusses the causes of the marvelous diversity of tropical forest biotas. Although little is said of the faunal constituents, the possible extrapolations are obvious and the zoological reader will surely find himself continuously making them. In Part 1, the writer is concerned with structure and physiognomy, and while much of the discussion is strictly botanical the fact that the subject of stratification is treated here makes this also a section of

direct concern to the student of the biome-type or of any of its animal components. Part 2 deals with the physical factors of the rain forest environment and includes an excellent account of tropical forest soils. Part 3 treats rain forest floristics and Part 4, the stages and dynamics of forest succession in the tropics. Part 5 reviews the tropical forest under peripheral, limiting conditions, as imposed by both latitude and altitude. While mainly descriptive, this part is suggestive of many stimulating questions concerning limiting factors generally. In spite of a growing tendency to emphasize instances of discordance in faunal and plant-formation distribution, the fact remains that repeated cases of coextensive distribution exist. Any effort to explain what sets the geographic limits of rain forest has bearing on the problem of faunal limitation as well. Part 6, "Man and the Tropical Rain Forest" is a single chapter summarizing what is known (and it is not very much) about secondary and deflected successions in the tropical parts of the world. The postscript is a plea for a retardation of man's destruction of the rain forests of the world, which Richards regards as not only an economic resource of immense importance but as a natural laboratory in which we could gain "a vast amount of scientific knowledge that could not be obtained elsewhere."

I might yield here to precedent and offer the customary approving reviewer's cliche about this being a book that ought to be on the shelf of every naturalist. As a matter of fact, though, I can conceive of some herpetologists and ichthyologists getting by indefinitely without cracking its covers. On the other hand, the student of any animal group who is seriously concerned with ecological relationships will find here a workman-like appraisal of the plant constituent of the most highly organized of all land environments; and to him the book is indispensable.—ARCHIE CARR, *Department of Biology, University of Florida, Gainesville, Florida.*

TRAITÉ DE PALÉONTOLOGIE, Tome V, Amphibiens, Reptiles, Oiseaux. Edited by J. Piveteau. Masson and Cie, Paris, 1955: 1, 114 pp., 979 figs., 7 pls. $37.00.—This handsome volume will be barred from the libraries of most individual purchasers by its fabulous price. This is a pity since, in spite of major defects, there does not now exist anything nearly comparable to this 1090-odd page attempted summary of what is known about fossil amphibians, reptiles and birds. Admirably printed, attractively bound, it would be valuable just as an atlas, since along with a few original figures it reproduces without reduction or diminution in quality many of the best figures and some of the classic plates of the osteology of both the Recent and fossil groups discussed.

Undoubtedly this work will be purchased by institutions, or indeed should be, as a major reference work. But if the casual reader is to use this as a reference work, a few cautionary remarks really should be pasted inside the front cover of each copy: the text is remarkably unequal and consequently a treacherous starting point for a beginner. This inequality of the various sections is in large part a result of a parochial attitude as regards contributors. In addition to the French corps of collaborators, of whom only Piveteau and Hoffstetter can be said to be authorities on any of the groups they describe, there are two Scandinavians and three Swiss, but no Germans, Englishmen or Americans. In certain cases this unwillingness to look east of the Rhine or across the English channel has resulted in conspicuous defects.

This treatise is uneven not only in the quality of its coverage of ths various groups but in the very erratic degree of modernity of its discussions. In some instances there must have been a very special effort made to include the latest papers and their illustrations, but in other instances much older literature has been missed or slighted.

The approach is almost strictly systematic, with only occasional remarks on the biology or functional morphology of the animals cited. Odd but not very instructive features are the short sections on representations of amphibians, reptiles and birds in paleolithic art.

Somewhat more than a third of the 990 pages devoted to amphibians and reptiles deal with the surviving groups. This is quite a fair proportion in a paleontological treatise. A considerable number of fossil groups, some very unfamiliar to the neoherpetologist, have a better fossil record than do the frogs, salamanders or Squamata. Nevertheless the neoherpetologist will have good reason to be disappointed in the treatment given in this book to several of the still living groups.

It is not perhaps surprising that the Gymnophiona with no known fossil representatives have received no discussion but it is not so easy to understand why on page 250 it is stated that the anurans and urodeles are the *only* Recent representatives—"les seuls representants actuels"— of the class Amphibia.

The section on the Anura by Piveteau contains a useful account illustrated by excellent photographs and lucid if rather crude interpretive sketches of the unique specimen of the oldest of all known frogs, the Triassic fossil *Protobatrachus*, all of this summarized from the 1937 description by Piveteau himself. Twelve pages are devoted to this form, the sole representative of the suborder Proanoura, almost twice the space given to the Euanoura, all the remainder of the frogs! As given here the Jurassic to

Recent history of the frogs is negligently and casually done.

To the neoherpetologist the preliminary portion of the frog chapter, on the skeleton, will seem especially weak. The figures are of *Rana* or *Ascaphus*; the text, as it states, deals primarily with *Rana*, commending the reader to other references for more substantial information. Need for brevity perhaps excuses this procedure, but it does not extenuate the bits of misinformation in so short an account, such as the remark that there are never more than nine vertebrae, when the existence of 10 in *Liopelma* and *Ascaphus* has long been known, or the attributing to *Ascaphus* and *Discoglossus* the persistence of "apophyses transversales" when obviously ribs are intended.

The urodeles, reported by Mlle Collette Dechaseaux (whose duty would seem to have been to tread where no one else would venture) have been slighted even more than the frogs. Their "general characters" (in reality the skeleton) are dismissed in a single page already half filled by two figures. Classification consumes half a page, the fossils are done in three, three-quarters of one of these three pages being spent on the story of the giant salamander of Oeningen, once thought to be a man drowned in Noah's flood. A few inconclusive paragraphs are added on the origin of urodeles and (by Piveteau) on the Wintrebert-Holmgren-Jarvik conception of a diphyletic origin of tetrapods. Nowhere is it indicated that a series of papers by Herre are the major recent studies on the paleontology of the group or that a paper of his (1950) contains a complete list of the fossil salamanders known to that date.

The chapter on turtles by Bergounioux is by long odds the worst in the book. It is particularly distressing to see radical errors enshrined in so impressive-seeming a reference work.

In 1938 a Permian concretion was described by Bergounioux as the earliest of all fossil turtles. The mistake was pointed out by Smith Woodward in a three-line note, yet it is here repeated. A footnote by Bergounioux complaining that Smith Woodward was misled by a bad photograph does not really rescue the situation. A further trivial point is that the generic name *Archaeochelys* Bergounioux 1938 applied to the concretion is preoccupied by *Archaeochelys* Lydekker 1889.

Repeated by Bergounioux from a 1935 paper is the ascription to the genus *Kinixys* (here called *Cinixys*) of a hinge in the plastron rather than in the carapace, with a consequent false record of the genus in the Oligocene of Europe. (Zoogeographers, please note.)

These two instances are not atypical. The text is unreliable both as to nomenclature and fact, and is in large part a republication without improvement of portions of previous papers by Bergounioux. However, the coverage of the literature is notably better than in his earlier attempts at monographing turtle faunas. Especially laudable is the inclusion of data from Zangerl's 1953 revision of the Toxochelyidae and Protostegidae. However, as a whole this chapter can only be described as unfortunate.

R. Hoffstetter treats the Rhynchocephalia and advanced Squamata and does so with much greater evidence of competence than is vouchsafed in the chapters previously cited. There is a very thoughtful discussion of the fossil history of the lizards as currently known, a history to which Hoffstetter has himself made important contributions and which has never hitherto been treated critically on a worldwide basis.

The Amphisbaenians are considered a distinct group coordinate in value with the lizards and the snakes. The classification follows that of Vanzolini (1951).

Hoffstetter believes that the snakes have separated at a very ancient period from the lizards and therefore rejects a platynotan origin. He rejects also a fossorial origin and believes that the snake ancestor was a grass dwelling form resembling in habitus though not closely related to *Pygopus*.

The subdivision of the snakes adopted by Hoffstetter is somewhat peculiar and based on levels of differentiation. Thus the Cholophidia comprise three families of Cretaceous to Eocene age, none of them certainly snakes. Scolecophidia is used for the Leptotyphlopidae plus Typhlopidae, and Alethinophidia for the more advanced snakes. The latter are subdivided into Henophidia for boids and their presumed relatives including the fossil families Paleophidae and Coniophidae and Caenophidia for colubrids and derived families. These groupings are admitted to be in part artificial but are defended on the ground that some suprafamilial units are provided and that certain classic names for such units are provisionally conserved. These classic "names" are, however, certainly unfamiliar to most herpetologists and the last two names are rather recent creations by Hoffstetter himself. In this as in other regards the discussion of the snakes seems less percipient than that of the lizards and may represent a less detailed personal knowledge.

However, though criticism of the Hoffstetter chapters is possible they suffer only by comparison with Kälin's work on the crocodilians.

Kälin's account has the tremendous advantage that to a far greater extent than in any other section of the volume it contains new material. It is a new and expert review of the evolution of an order, at once critical and synthetic. There are, refreshingly enough, a number of excellent original figures,

along with many photographs and copied figures. His conclusions, whether or not they can be accepted in their entirety, are very lucidly stated and clearly expose the bases for his taxonomic judgments.

There is a diagram of the putative phylogeny of the families within the order. (This is a useful device all too rare in this volume.) The order and every major subdivision and many of the genera are clearly defined. There is a comparative table (to the family level) of the various classifications which have been proposed for the Crocodilia, a list of 26 primitive versus 26 advanced characters occurring within the order, and a tabular record of the occurrence of each of these 26 alternatives in each of the families recognized.

Of special interest to neoherpetologists is the recognition of only two surviving families, the Gavialidae and the Crocodylidae. As he had already stated in 1931 Kälin regards the gavials as a very distinct and ancient line. His phyletic diagram indeed suggests independent origin from the Triassic protosuchids!

In regard to the wholly extinct groups Jarvik on the Ichthyostegalia and Peyer and Kuhn-Schnyder on Placodontia and the so-called squamates of the Trias are dealing with groups of which they have intimate first hand knowledge, being in fact the veritable world experts in these fields. They succinctly summarize previous more extended accounts and reproduce most of their own best illustrations.

The remaining sections are collations of the literature by non-experts and are therefore strongest where there has been a recent good review. Thus much of the cotylosaur section as written by Piveteau is almost a direct translation (with due credit) of a paper by D. M. S. Watson (1954) and Watson's pictures are similarly taken over almost entire. (In the discussion of *Archaeopteryx*, again by Piveteau, much the same is done with De Beer's 1954 monograph.)

The "generalities" on Amphibia by Lehman is far more complete and in all respects much superior to the singularly feeble section on reptilian generalities by Piveteau. Lehman follows Romer for the most part in well illustrated sections on the Rachitomi and the Anthracosauria. A divergence from Romer is the recognition of a phyllospondyl group, to which a special chapter is given. Despite Romer's contention dating from 1947 that the phyllospondyls were an unnatural group composed of larval types, no counter argument is presented, and the only mention of Romer's opinion is an obscure half sentence. Mlle Collette Deschaseaux on Lepospondyls and Ichthyopterygia and Piveteau and Mlle Deschaseaux on trematosaurs and stereospondyls summarize the literature well and have selected a very good series of figures. Saint Seine does a similar job for the Sauropterygia and Pterosauria, and Hoffstetter for the thecodonts.

Lapparent and Lavocat on dinosaurs may have somewhat overemphasized this group. Their chapter is lengthy and discursive and introduces a remarkable amount of biological miscellany. Within its limits, however, as a collation of the literature it must be considered quite useful.

This last judgment is probably the appropriate verdict for the major portions of this book. In total effect this is an attractive volume. To be counted against it are its price, the neglect of many foreign experts, and an overall editorial policy by Piveteau that has neglected coordination of the whole in favor of a mere routine filling in of gaps. To be counted in its favor are the inclusion within one pair of covers of an enormous mass of information, large bibliographies, and truly abundant illustrations and as a bonus a number of articles by the real experts on the groups.—ERNEST E. WILLIAMS, *Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts.*

THE NATURAL HISTORY OF NORTH AMERICAN AMPHIBIANS AND REPTILES. By James A. Oliver. D. Van Nostrand Co., Inc., Princeton, New Jersey, 1955: ix + 359, 12 pls., 74 figs. $6.95.—This authoritative book will be read with enjoyment and profit by amateur and professional herpetologist alike. Intended primarily for the beginning student and the naturalist, this work is a compilation of the ways and habits of the reptiles and amphibians of the United States and Canada. As such it represents a novel adjunct to as well as a radical and certainly welcome departure from the more frequently encountered handbook type of publication which concerns itself principally with identification and only sketchily outlines life history details, if at all.

The scope of the book is wide as indicated by the thirteen chapter headings which deal respectively with Folklore, Economic Values, Classification, North American Amphibians, North American Reptiles, Occurrence of Amphibians and Reptiles, Locomotion and Movements, Activity, Relation to Environment, Food and Feeding, Reproduction, Growth, Size and Longevity and Amphibians and Reptiles as Pets. There is also appended a glossary and a list of recommended references. It is to be regretted that the author found it unnecessary or perhaps impossible to include a bibliography for in many ways this would have been of considerable benefit to the student.

The more advanced amateurs and students will find much food for stimulating thought previously unavailable to them in such conveniently sum-

marized and compared form. In promoting further interest and worthwhile observations and research into the life histories of captive and feral amphibians and reptiles, Dr. Oliver's book will be a basic and needed tool of newcomers to the field for some time to come.

Errors are extremely few and the printing job and format of the book are excellent. Omissions of important literature from such a vast and complex field as that covered seem not to have occurred and are a testimony to the very thorough survey of the field by Dr. Oliver. The result of his painstaking effort is a lucid and easily readable account that cannot be too highly commended.—CHARLES E. SHAW, *Zoological Society of San Diego, San Diego 12, California.*

A CENTURY OF PROGRESS IN THE NATURAL SCIENCES. By Robert C. Miller, Edward L. Kessel, and G. F. Papenfuss (Committee on Publication), California Academy of Sciences, San Francisco, 1955: x + 807. $10.00 (Cloth).—As a part of the celebration of its Centennial, the California Academy of Sciences gave to the world this informative volume that broadly covers the history of biosystematics from 1853 to 1953. This was an exciting century for natural history containing, as it did, the rich and significant contributions of Darwin, Wallace, Mendel and scores of other brilliant biologists.

Only the first two chapters, comprising about ten percent of the pages, are locally oriented with reference to the Academy. The remainder is devoted to the stories of the significant developments, during the last century, in the various taxa of animals and plants. The major groups of plants, four of the classes of vertebrates, and the insects are covered. It is unfortunate that the Committee did not include chapters on the fishes, arthropods (other than insects), molluscs and echinoderms. In addition, there are several chapters cutting across those devoted to phylogenetic groups. That on animal geography is by Karl P. Schmidt and the conservation of wildlife is by A. Starker Leopold.

The 38 page illustrated chapter on herpetology will be of most interest to the readers of *Copeia.* In writing this history, Karl P. Schmidt selected wisely from his vast knowledge of the foreign and American literature of both recent and past years. Rather than treating his material in a strictly chronological fashion, Schmidt used a subject-matter approach. For example, some of his sub-titles are: The Era of Dumeril and Bibron, the Boulengerian Era in Europe, Herpetology at University Museums, Lithographic Illustration of Amphibians and Reptiles, The Amateur in Herpetology, and The Study of Snake Venom. The bibliography contains four dozen references, largely biographical in nature. I am sure that most herpetologists will find this a delightful and instructive account. My only regret is that it is not more extensive.

The book is marred by some typographical errors which may dismay a purist but will not disturb a serious student reading for information. In the foreword it is stated that the Committee is confident that the volume will long serve as a most valuable source book in the history of science. The present reviewer shares this confidence and congratulates the Academy on a signal achievement.—ARNOLD B. GROBMAN, *Florida State Museum, Gainesville, Florida.*

DIE AMPHIBIEN UND REPTILIEN SÜDWESTAFRIKAS. Aus den Ergebnissen einer im Jahre 1952 ausgeführten Reise. By Robert Mertens. Abh. Senck. Naturf. Ges., No. 490, 171 pp., 24 pls., 1 map (price not stated).—The herpetological fauna of the formerly German southwest African territory, mandated after World War I to the Union of South Africa, is a rich one, highly interesting for the adaptations to desert life of many forms. There are 23 species of frogs, 8 turtles, a single crocodilian, 89 lizards, and 52 snakes (without enumeration of the sub-species). The determination of new material had become difficult on account of the widely scattered literature, with descriptions and reports in English, German, and French journals. In recent years W. Hoesch and J. Gaerdes have sent some material to American museums, as well as to the Senckenberg Natur-Museum in Frankfurt a/M.

Dr. Mertens has brought order into this zoological tangle by means of a scholarly work that considers the history of herpetological studies, a summary of taxonomic changes, and a discussion of questionable records, with essays on the zoogeography and ecology of the amphibian and reptile fauna. There follows a well-documented "complete list" of the amphibians and reptiles, together with keys for the identification of the genera and species of each family. The illustration, with photographs from life, and of preserved specimens, and with a magnificent pair of landscape illustrations in color, is distinguished. Twelve new forms based on material in the Senckenberg collections were described in preliminary papers in 1954.

American herpetologists will not like the introduction of the meticulously etymological term taxionomic (for taxonomic). *Taxinomic,* as a matter of fact, as a more correctly derived form, has been used in English, but has never been current. It is in the spirit of the English language to regard usage as the major criterion of correctness, and taxonomy and taxonomic have the sanction of more than a century of currency, since De Candolle.—KARL P.

SCHMIDT, *Curator of Zoology Emeritus, Chicago Natural History Museum, Chicago, Illinois.*

FISH MORPHOLOGY AND HIERARCHY. Parts II and III. (For Part I see *Copeia*, 1956: 66.) By Kiyomatsu Matsubara. 1955. (In Japanese.)—Part II, of 815 pages, continues the systematic accounts and keys from the ophidioids through the angler fishes. This section is followed by 15 pages of general references, 19 pages of English glossary with equivalents and definitions in Japanese, and separate indices for scientific and Japanese fish names. Part III, bound separately, contains 135 plates with 461 figures of fishes in black and white republished from various sources. Parts II and III are sold together for approximately $15.00.

KEY TO THE FISHES OF INDIANA. By Shelby D. Gerking. Investigations of Indiana Lakes and Streams, 1955, 4: 49–86.—Deals with 174 species (including *Moxostoma breviceps* and *Notropis dorsalis*, expected but not definitely recorded from the state) in 29 families and 71 genera. Subspecies are recognized in 11 species, making 185 forms. The format and much of the dichotomy is taken from Hubbs and Lagler. *Petromyzon marinus* and *Carpiodes forbesi* have been added since 1945. Recent nomenclatorial changes have been adopted (e.g., *Ameiurus* = *Ictalurus*, *Schilbeodes* = *Noturus*, *Leucichthys* = *Coregonus*, and *Clinostomus* = *Gila*). There is an annotated list of new distribution records for the 130 collections made since 1945, when the author's distributional study appeared. A key to the families is followed by a key to the species, each of which is given a common name. There are no illustrations.

COLOURED ILLUSTRATIONS OF THE FISHES OF JAPAN. By Toshiji Kamohara. Hoikusha, Osaka, Japan, 1955: xi + 135, 64 col. pls.—Another book of color plates of Japanese fishes of the type put out in Japan so frequently and so well. As compared with Tanaka's "Japanese fishes in life colors" (1931) or Okada, Uchida, and Matsubara's "Illustrated text of Japanese fishes" (1935; see *Copeia*, 1955: 245) Tomiyama's figures appear a bit gaudy and stylized. How well they actually depict the fishes is impossible for one unacquainted with the Japanese fauna to say.

REPTILES OF WEST AFRICA. By G. Cansdale. Penguin Books, London, 1955: 104 pp., 8 figs.

LES METAMORPHOSES DES BATRACIENS. By P. C. J. Roth. Les Heures Scientifiques, Durod, Paris, 1955: 98 pp., figs.

A BIBLIOGRAPHY ON THE VERTEBRATE FAUNA OF IRAQ AND NEIGHBORING COUNTRIES. III. Reptiles and Amphibians. IV. Fishes. Iraq Natural History Museum, Bagdad, 1955.

FISH SAVING, A HISTORY OF FISH PROCESSING FROM ANCIENT TO MODERN TIMES. By Charles L. Cutting. Philosophical Library, N. Y., 1956: xv + 372, 45 pls., 16 figs. $12.00.

DISEASES OF FISHES. By C. van Duijn, Jr. Water Life, Dorset House, London, 1956: xiii + 174, illus. $2.15.

SNAKES AND SNAKE CATCHING IN SOUTHERN AFRICA. By R. M. Isemonger. Publ. by Howard B. Timmins, 58 Long Street, Cape Town, 1955: 106 pp., 50 illus.

ESSAYS IN MARINE BIOLOGY. Edited by S. M. Marshall and A. P. Orr. Oliver and Boyd, Edinburgh, 1953: vii + 144, figs. $1.75.

NORTH AMERICAN PRAIRIE. By J. E. Weaver. Johnsen Publ. Co., Lincoln, Neb., 1954: xi + 348, 87 figs., $5.00.

THE SNAKES OF INDIA AND PAKISTAN. By K. G. Charpurey. Popular Book Depot, Bombay, 1954: vi + 154, 76 figs.

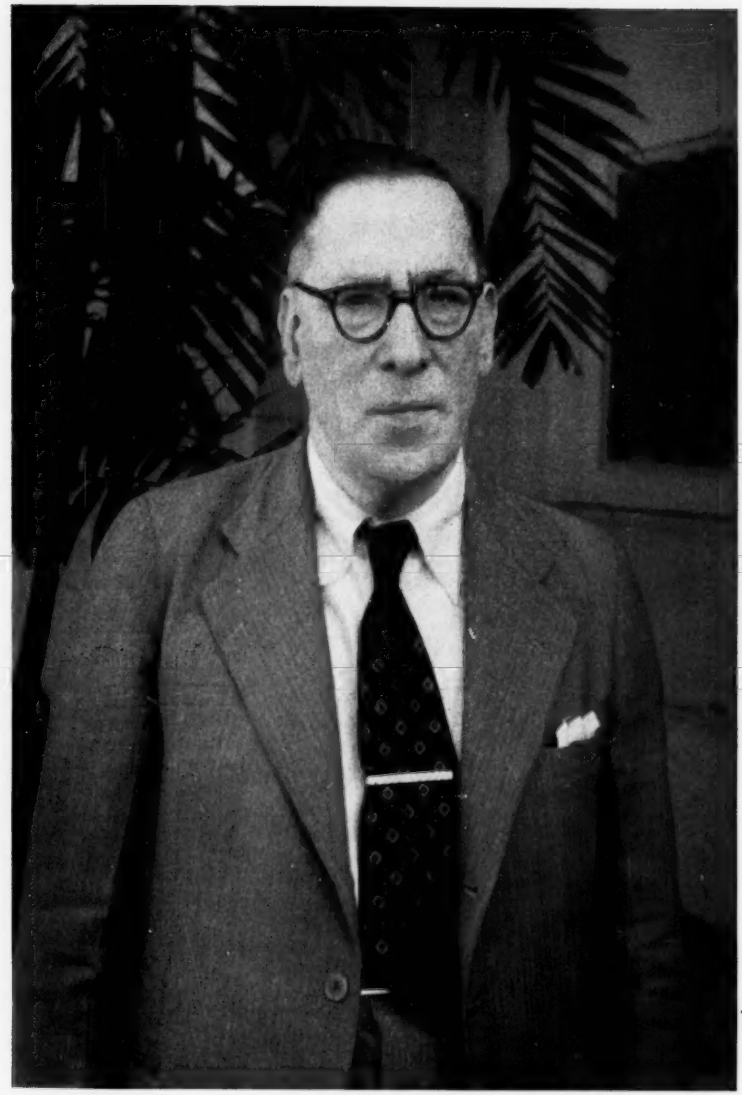
THE WORLD AQUARIST. A quarterly journal published by World Federation of Aquarists, Administrative Center W.F.A., % W. Veldhuizen, 37, Stieltjeslaan, Hilversum, Netherlands. Vol. 1, 1955.

EDITORIAL NOTES AND NEWS

SUNDER LAL HORA

The sudden death of Dr. Sunder Lal Hora, Director, Zoological Survey of India, Calcutta, on December 8, 1955, comes as a great shock to his many friends and colleagues throughout the world. A very brilliant star in the world of science has been extinguished, and ichthyology in particular is rendered poorer by the loss of one of its most accomplished devotees. His death has also left a gap in the scene of Indian zoology which will be hard to fill.

Born in Hafizabad, Punjab, on May 2, 1896,



Photograph by L. P. Schultz

Dr. Sunder Lal Hora, Dec. 2, 1953, Calcutta

Hora studied at the Das-Anglo Sanskrit High School, Jullunder, and later attended the Government College, Lahore, of the Punjab University. On a visit to Lahore in 1919 Dr. Nelson Annandale, founder and then Director of the Zoological Survey of India, saw in Hora great promise and invited him to Calcutta to continue researches as an associate. The distinguished Indian Zoologist Dr. Baini Prashad was already working in Calcutta and after Hora's arrival, Drs. B. N. Chopra and H. S. Rao joined their ranks in the early twenties, to form a select band of Indian zoologists who received their training from Annandale. At the Survey, Hora was appointed Assistant Superintendent in 1921 in charge of ichthyology and herpetology and later became Superintendent and in 1947, when Prashad was called to advise the Government on matters of fisheries development in India, Hora became Director.

Hora's prolific output of research began with a faunistic study of "The Fish of Seistan," written in 1920 in collaboration with Annandale. In recent years, despite heavy administrative duties, frequent travels and other preoccupations he continued his interest in research with the same vigour and at the time of his death had published over four hundred scientific papers on a great variety of subjects, mainly dealing with various aspects of ichthyology. He had an abiding interest in the study of animal ecology, adaptation and evolution and later became concerned with zoogeographical and palaeogeographical problems.

Hora always recalled with love and gratitude the lasting influence Annandale had on his thought and early scientific development; for, from him he acquired an insatiable curiosity to delve into the habits and habitats of the animals that he came across. Annandale advocated a policy, whereby each member of his staff had the opportunity of spending a few months every year in the field and Hora himself availed of this from the very beginning and developed an uncanny knack for selecting problems in the field which were worthy of intensive laboratory study. To him animals were complex systems interacting always with the almost equally complex and ever-changing environment. Hence it is no wonder that his writings, whether they be in systematic ichthyology or in faunistic studies are all impregnated with much valuable data gained through field observations. This quality marked him as an outstanding field naturalist.

It was while engaged in a field survey of the Manipur Valley in the eastern Himalayas (Assam) with Annandale that Hora was first struck by the amazing adaptations of animals inhabiting the hill-streams. Subsequently, both studied the adaptive modifications of fishes and batrachians inhabiting the hill-streams. These researches were among the foundations on which Hora's opinions on the broad zoological questions of adaptation and evolution later became resolved. His work on the torrential fauna culminated in a monograph on the "Ecology, Bionomics and Evolution of Torrential Fauna, with special reference to the organs of attachment" (Trans. Roy. Soc. London (B) 218: 171–282), which will remain a classic on account of its masterly exposition. He felt that the unit of evolution is not an individual, much less a chromosome, but that the entire population is affected by some external factors and hence that evolution may be defined as "an *increase* in the capacity of a group of individuals to respond to the changes in the environment in a way more suitable to the conditions of existence."

He was critical of the usage of the term "non-adaptive characters" and would rather have them labelled as "uninvestigated characters." He considered "preadaptation" as partly explaining how certain animals could colonize difficult situations, or "dynamic environmental conditions" such as a torrential environment, or the breaker zone close to the shore, where everything is subordinated to the environment. His views on convergent and divergent evolution are well expressed not only in his works on the hill-stream fauna, but also in his studies of the evolution of the air-breathing fishes and the adaptations of the gobioid fishes of the Gangetic estuary. He attributed the marked resemblance of the homalopterid and gastromyzonid fishes, to an extreme case of convergence and deduced the origin of the two groups which he later treated as phyletically separate families, the former evolved from the Cyprinidae and the latter from the Cobitidae.

Early in 1927 he contemplated a much-needed revision of Day's "Fishes" in the Fauna of British India series, but his various other activities interfered. However, his many faunistic studies and revisions of Oriental cyprinoid and siluroid fishes will serve as a foundation for any future comprehensive work on Indian fishes.

Hora's researches of hill-stream fishes led him on to zoogeographical and palaeogeographical studies and in 1937 he propounded the "Satpura hypothesis" to explain the occurrence in Peninsular India of fishes closely allied to those of the Malaya Peninsula. His attack on this problem became a collaborative synthesis of biological, meteorological, geological and geographical data which led to a meaningful interpretation of a considerable amount of faunistic and taxonomic data. Although opinions may slightly differ as to the different time of migration indicated by Hora, the major part of his thesis remains irrefutable.

Hora became interested in fisheries while doing the "Fish and Fisheries of Manipur . . . ," in 1920.

Between 1942 and 1947, as Director of Fisheries, Bengal, he was able to further his interests in this field and before long was recognized as a leading exponent of pond culture of freshwater fishes and, at the time of his death had completed an extensive treatise on the subject. Many in America will remember his last visit to this country, when under the auspices of the United Nations, he opened a discussion on "Pond Culture of Warm Water Fishes" at Lake Success in 1949. His advice on fishery matters was always sought by the Government of India, by the different State Fishery officials in India, and by fisheries biologists from other countries. He represented India in many international fisheries conferences.

A born naturalist, Hora's interest in wildlife conservation can be well understood. As Honorary General Secretary of the Indian Board for Wildlife Conservation, he helped a great deal in the formulation of plans for more judicious methods of wildlife conservation, for the formation of National Parks, etc.

Hora became deeply interested in assessing the knowledge of ancient Hindus concerning the fishes and fisheries of India, with the idea of tackling fishery problems in India today against the background of the wealth of traditional knowledge that had hitherto remained buried in Pali and Sanskrit literature. His many contributions on this theme were published by the Asiatic Society of Bengal.

Hora's pre-eminence in the field of biology in Asia was well recognized and he was honoured by various scientific bodies both in India and abroad. He recalled with pleasure his election as an Honorary Foreign Member of the American Society of Ichthyologists and Herpetologists. The highest honour that his country and fellow scientists could bestow on him was accorded him in 1954, when he was elected General President of the Indian Science Congress Association for that year.

As a man, Hora was well above medium height and of heavy build. During college days he distinguished himself in the athletic field. He was quite unassuming and possessed a rare blend of humility and kindness. He was an excellent speaker and writer, a good conversationalist and had a capacious mind. As an administrator, he was mildly firm but no dictator. He was always ready to praise the scientific success of his colleagues, and gave every encouragement to members of his staff and pupils who will always remember him as a wise and friendly counselor and a revered master. In keeping with the tradition handed down to him by his distinguished predecessors, he kept the Zoological Survey of India in the forefront of institutions of its kind in the world, and as a center for zoological research in India.

Early in 1953 he suffered a heart attack, but recovered. Not being one to be downed by circumstances, he soon resumed the full swing of activity. His tireless activity after illness was astounding. Nothing could diminish his ardor for work. For such a soul, nothing is more befitting than to face the end while in the line of duty. On December 6, while addressing a meeting in the Asiatic Society of Bengal, he had a second stroke and passed away two days later. It is unfortunate that time ran so short that he could not fulfill some of his major projects.

Only those who knew the Horas well can say how much he and science owed to his wife's sympathetic understanding and her devoted care of him during and after his period of illness in 1953. He is survived by her and by one son and two daughters.

In this brief notice, I am able to give only a glimpse of the many sided activities of a versatile genius and a great teacher—one who has been a great asset to his country and to science in general. —E. G. Silas, *Scripps Institution of Oceanography, University of California, La Jolla, California*, and, *Trivandrum, Travancore-Cochin, India.*

Daniel Giraud Elliot Medal

AWARD of the Daniel Giraud Elliot Medal of the National Academy of Sciences to DR. ARCHIE CARR of the University of Florida in recognition of his "Handbook of Turtles" was announced February 2 by the President of the Academy, DR. DETLEV W. BRONK.

The Elliot Medal has been awarded by the Academy annually since 1917 under a provision of the will of DANIEL GIRAUD ELLIOT expressing his wish to provide a medal and honorarium to the author of any paper, essay, or other work published each year in zoology or paleontology and judged by the Academy to be of outstanding merit.

Senckenberg Museum, Frankfurt am Main, Germany

A COMPREHENSIVE account of the amphibians and reptiles of Southwestern Africa by DR. ROBERT MERTENS, has been published in "Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft" (No. 490, 1955). The extensive material collected by DR. MERTENS during the winter of 1954–55 in Brazil, Peru, and Venezuela has arrived in Frankfurt. The investigations on the difficult Peruvian *Tropidurus* are already terminated and in press. The herpetological collection, brought from the Galapagos Islands by DR. EIBL-EIBESFELDT with the "Xarifa" Expedition, has been received. DR. EIBL has described a remarkable new form of *Amblyrhynchus cristatus*. Another important acquisition is the herpetological collections of the Museum

at Bogor from A. M. R. WEGNER's explorations of the islands of the Krakatau group and of the little known district Udjung Kulon of western Java; DR. MERTENS is now working on this material. As guest investigator, DR. MUHTAR BASOGLU of the University of Istanbul, Turkey, is preparing a checklist of the amphibians and reptiles of Turkey.

DR. W. KLAUSEWITZ, the ichthyologist of the Senckenberg Institute, has recently returned from a voyage to Greenland. Besides working on his material from Greenland, he is arranging and revising the great ichthyological collections, which are partly still in storage since World War II.

Virginia Fisheries Laboratory

THE staff of the Virginia Fisheries Laboratory has been augmented recently by two new appointments. DR. WILLIAM J. HARGIS, JR., joined the staff in September 1955, and JAMES P. WHITCOMB arrived in February 1956. DR. HARGIS has specialized in the systematics, phylogeny and host-specificity of the trematode parasites of fishes. His new duties are concerned primarily with the life-histories of oyster drills, but he is continuing his studies of fish parasites. MR. WHITCOMB has served for the past five years on the staff of the Marine Biological Laboratory at Woods Hole, Massachusetts. He will be employed in studies of the commercial pound-net and haul-seine fisheries.

The Laboratory executed a contract in February 1956 for the construction of a 55-foot wooden research vessel. Similar in design to a southern shrimp-trawler, the boat will have living accomodations below decks for six people, and a laboratory on the main deck. She will probably be launched in the fall of 1956.

McLane Collection

DR. WILLIAM M. MCLANE'S ichthyological collection, approximately 1,560 lots representing at least 140 species or a total of some 21,700 specimens, has been donated to the University of Florida. Most of the material is from the southeastern states and Cuba with particular emphasis on Florida freshwater forms. The University of Florida Fish Collection, containing about 88,000 catalogued specimens of 550 species is under the joint administration of the Florida State Museum and the Department of Biology. Many locally common fishes are available for exchange with other institutions. Write to: Curator of Fishes, Room 1, Flint Hall, University of Florida, Gainesville.

Bulletin of the Florida State Museum

VOLUME 1, Number 1, of a new biological journal, "Bulletin of the Florida State Museum, Biological Sciences," was published in January, 1956. This number, a 72-page article by T. H. HUBBELL, A. M. LAESSLE and J. C. DICKINSON, is entitled "The Flint-Chattahoochee-Apalachicola Region and Its Environments." This is the first of a series of articles on a survey of an area of special interest from a zoogeographic viewpoint. The editor of the Bulletin is DR. WILLIAM J. RIEMER, Assistant Curator of Biological Sciences in the Museum. DR. JOHN C. BRIGGS, Department of Biology, University of Florida, is associate editor. Requests for information concerning exchanges or subscriptions should be addressed to the Curator of Biological Sciences, Florida State Museum, Seagle Building, Gainesville, Florida. Manuscripts may be sent to the editor.

University of North Carolina

DR. EARL E. DEUBLER, JR. has accepted appointment to the regular faculty of the University of North Carolina Institute of Fisheries Research, Morehead City, North Carolina, in the rank of Assistant Professor. DR. DEUBLER will investigate the early life histories of marine fishes with emphasis on larval development.

The Status of Copeia

THE 1956 budget for the publication of Copeia is $5,940.00; the amount expended in 1955 was $7,253.00. The operating cost increases by about 13 percent with publication of this issue. This decrease in available funds and increase in publication costs has not been accompanied by a decrease in the number of manuscripts available for publication. The editors are restricted to the publication of 225 pages in 1956.

The Editor-in-Chief urgently requests the cooperation of all authors in the following matters: (1) the presentation of subject matter briefly and clearly; (2) the preparation of manuscript in the correct format for publication; (3) deletion of all possible illustrations, charts and tables; (4) the prompt response to correspondence.

Printing Deadlines for Copeia

THE editors desire to print items in "Editorial Notes and News" and "Reviews and Comments" in the first number printed after they are received. If copy is in the office of the Editor-in-Chief by the dates indicated, it will appear in the next issue: No. 3, June 12; No. 4, Aug. 20. Copy received between these dates and the date of publication can be inserted only at considerable extra cost to the Society.

Recent Deaths

DR. EMMETT REID DUNN, the David Scull Professor of Biology and Chairman of the Department of Biology at Haverford College, died

February 13 after a long illness. A review of DR. DUNN'S contributions to zoology will be published in Copeia.

DR. LÉON BERTIN, ichthyologist of the Museum d'Histoire naturelle à Paris, was killed early in February when his car skidded on an icy road and struck a tree.

DR. E. W. GUDGER, age 89, well-known ichthyologist, died February 19 at Waynesville, North Carolina.

Gift in Memory of Emmett Reid Dunn

A GIFT to the Society of one hundred dollars in memory of EMMETT REID DUNN, Editor of Copeia, 1924–1929, has been designated for the 1956 publication fund by a donor who wishes to remain anonymous.

Mary Clark Thompson Medal

THE Mary Clark Thompson Medal of the National Academy of Sciences for 1954 has been awarded to DR. ALFRED S. ROMER of Harvard University for his outstanding contributions to paleontology.

The Mary Clark Thompson Medal was established in 1919 by Mrs. Thompson to provide a substantial reward for distinguished services to geology or paleontology.

University of California Los Angeles

THE Ichthyology-Fisheries group, quartered in a new $3,300,000 Zoology Building, have 4,000 sq. ft. of space and an equipment storage building. The facilities include a classroom with running sea-water, an aquarium room with temperature controls and circulating seawater, a fish collection room, a cataloguing room, a library, and five research laboratory rooms. The building contains complete facilities for zoological research and these are shared by the fisheries group. Special additional facilities for research in fish behavior and physiology are planned.

DR. BOYD W. WALKER, in charge of the fish work, is continuing his research on tropical eastern Pacific shore fishes. MR. WAYNE BALDWIN is reviewing the eastern Pacific puffers with DR. WALKER. DR. LARS H. CARPELAN, DR. RICHARD R. WHITNEY, DR. L. J. HENDRICKS, MR. RICHARD LINSLEY and MR. JAY C. QUAST are working on the Salton Sea Research Program. This research, supported by a grant from the California Department of Fish and Game, from funds provided by the Wildlife Conservation Board, is aimed at establishing a sports fishery in the Salton Sea. DR. CARPELAN is studying the physical and chemical characteristics and the plankton. DR. WHITNEY and DR. HENDRICKS are studying the fishes of the sea and MR. LINSLEY is working on the larger invertebrates. MR. QUAST is working part time on an intensive food study of the Gulf croaker.

MR. KENNETH S. NORRIS, Curator of Fishes at Marineland of the Pacific, is studying the temperature relations of *Girella nigricans* on a National Science Foundation Fellowship through this department.

Students working towards the Ph.D. degree include: MR. WILLIAM N. MCFARLAND is studying the effects of hypnotics on fishes; MR. RICHARD H. ROSENBLATT is reviewing the tripterygid fishes; MR. JAY C. QUAST is reviewing the hexagrammoid fishes; MR. GEORGE BARLOW is studying the geographical variation in morphology and physiology of the gobioid genus *Gillichthys*; and MR. FREDERICK W. MUNZ is studying the visual pigments of fishes. MR. N. MAHADEVA, from Ceylon, is finishing his Ph.D. thesis on a review of the genus *Symphurus* from the eastern Pacific. MR. JOHN S. STEPHENS, JR., MR. PETER W. GLYNN, and FATHER P. V. K. THEOBALD (India) have not as yet selected problems. MR. SUBODH K. CHAKRABORTI (Pakistan) and MR. S. F. KITAGAWA are working towards the Master's degree.

A.S.I.H. Western Division

THE WESTERN DIVISION will hold its 1956 meeting in conjunction with the Pacific Division of the American Association for the Advancement of Science at Seattle, Washington, during the week of June 11–16.

The meetings, including a joint session with the Herpetologists League, will be scheduled for Wednesday and Thursday, June 13 and 14, with submitted papers on Wednesday morning and afternoon, a symposium on fish physiology on Thursday morning, and business meeting and submitted papers on Thursday afternoon.

Financial Report for Calendar Year 1955

By Coleman J. Goin, Treasurer

Checking Account

Balance on hand, Citizen's Bank of Gainesville, January 1, 1955		$ 3,149.84
Receipts		
Memberships Received		
Current dues for 1955	$1,011.02	
Back dues for 1954	5.00	
Advance dues for 1956 and beyond	4,271.40	
		5,287.42
Subscriptions Received		
Current 1955	670.30	
Advance, 1956 and beyond	1,414.21	
		2,084.51
Back numbers of Copeia sold		
Publications Secretary (Huntington)	798.39	
Secretary (Gainesville)	24.48	
		822.87
Interest—Stoye Fund Bonds		76.30
Interest—Endowment Bonds		102.60
Contributions		
Dept. Fisheries, Province of Quebec (Copeia)	250.00	
Roger Conant (Postage, Divisional Groups)	50.00	
W. A. Gosline (General)	50.00	
L. M. Klauber (Western Div. Prizes)	30.00	
C. L. Hubbs (Western Div. Prizes)	30.00	
George P. Meade (General)	25.00	
Anita Daughtery (General)	25.00	
L. M. Klauber (General)	10.00	
Miscellaneous contributions	13.75	
		483.75
Charges for use of Mailing List		107.00
Postage Refunds		5.40
Payment for Illustrations in Copeia		40.00
Return from Annual Meeting		32.24
Overpayment on Life Membership		25.00
Total		$12,216.93

Expenditures and Disbursements

Cost of publication of Copeia		
1955, no. 1	$1,783.38	
1955, no. 2	1,650.78	
1955, no. 3	2,205.76	
1955, no. 4	1,612.78	
		7,252.70
Printing		452.84
Stenographic Services, Secretary, Gainesville		150.00
Social Security		2.00

Postage and Incidentals		
Secretary	100.00	
Editors	150.00	
		250.00
Contributions		
Remittance of 40 pounds to Zoological Society to assist in publication of "Zoological Record"		113.60
Reimbursement 1954 Treasurer's bond	5.00	
Treasurers bond, 1955	5.00	
		10.00
Travel, Secretary (San Francisco)		450.00
Anita Daughtery (West. Div. Prizes)		60.00
Shipping charges (Huntington)		6.93
Bank charges		3.36
West. Division postage		25.00
Refunds for overpayments		37.50
Dues, American Institute of Biological Sciences		695.50
Stoye Prizes awarded at Annual Meeting		
George W. Barlow (Ich.)	25.00	
Jay C. Quast (Ich.)	12.50	
		37.50
Total Expenditures		$ 9,546.93
Balance on hand, Citizen's Bank, December 31, 1955		2,670.00
Total		$12,216.93

ENDOWMENT FUND

Balance on hand, First Federal Savings and Loan Association, January 1, 1955	$ 2,541.50
Received from members for life memberships	820.00
Received from sale of Check List	135.15
Interest from savings account	78.23
	3,574.88
Less Purchase of Bond for Endowment Fund	1,000.00
Balance on hand December 31, 1955	2,574.88

REVOLVING RESEARCH FUND

Balance on hand, Florida Bank of Gainesville, January 1, 1955	535.25
Contributions	
M. B. Mittleman	25.00
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	565.25
Less grant to Ralph W. Axtell	100.00
Balance on hand, Florida Bank of Gainesville, December 31, 1955	$ 465.25

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